SMITHSONIAN

Miscellaneous Collections

VOLUME XLVII

(QUARTERLY ISSUE, VOLUME II)

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN."—SMITHSON.

No. 1573.

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1905

Press of
The New Era Printing Company
Lancaster, Pa.

The present series, entitled SMITHSONIAN MISCELLANEOUS COLLECTIONS, is intended to include all the publications issued directly by the Smithsonian Institution in octavo form, excepting the ANNUAL REPORT; those in quarto constituting the SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE. The quarto series includes memoirs embracing the records of extended original investigations and researches, resulting in what are believed to be new truths and constituting positive additions to the sum of human knowledge. The octavo series is designed to contain reports on the present state of our knowledge of particular branches of science; instructions for collecting and digesting facts and materials for research; lists and synopses of species of the organic and inorganic world; museum catalogues; reports of explorations; aids to bibliographical investigations, etc., generally prepared at the express request of the Institution, and at its expense.

In the CONTRIBUTIONS TO KNOWLEDGE, as well as in the MISCELLANEOUS COLLECTIONS, the actual date of the publication of each article is that given in the Table of Contents, and not necessarily that of the volume in which it appears.

The *Quarterly Issue* of the SMITHSONIAN MISCELLANEOUS COLLECTIONS is designed chiefly to afford a medium for the early publication of the results of researches conducted by the Smithsonian Institution and its bureaus, and especially for the publication of reports of a preliminary nature.

S. P. LANGLEY,
Secretary, Smithsonian Institution.

CONTENTS.

ILLUSTRATIONS.

Volume XLVII

Smithsonian

Miscellaneous Collect

VOLUME 2 QUARTERLY ISSUE

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1904

SMITHSONIAN MISCELLANEOUS COLLECTIONS

QUARTERLY ISSUE

The Quarterly Issue of the SMITHSONIAN MISCELLANEOUS COLLECTIONS is designed chiefly to afford a medium for the early publication of the results of researches conducted by the Smithsonian Institution and its bureaus, and especially for the publication of reports of a preliminary nature. It is not designed that the Quarterly Issue shall supersede the regular series of the SMITHSONIAN MISCELLANEOUS COLLECTIONS, but, as the name implies, shall form a part thereof.

Following the long established custom of the Institution, all contributions submitted for publication in the Quarterly Issue will be referred to a committee, on whose judgment of the value and suitability of such contributions the Institution will be guided.

The Quarterly Issue will be published about the first of January, April, July, and October. Each number will consist of about 144 pages and will be suitably illustrated.

CONTENTS

VOL. 47 1904

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 2 QUARTERLY ISSUE PART I

THE ABSORPTION OF WATER VAPOR IN THE INFRA-RED SOLAR SPECTRUM

BY F. E. FOWLE, JR.

(Communicated by S. P. Langley, Secretary of the Smithsonian Institution.)

PURPOSE OF THE PAPER

The quantitative investigation of the relationship between the amount of water vapor in the terrestrial atmosphere and the corresponding changes in the transmissibility of the latter to the incoming solar energy, is the primary object of this paper. Bouguer's formula, which will later be treated in detail, furnishes an analytical means for this study. As generally used, however, it would indicate that the absorption depends only on the amount of vapor present as an absorbent; that is, the same absorption would be produced by a given quantity of water in the form of vapor, whether the path were long through a small density, or short through a great density. In order to determine spectroscopically the amount of aqueous vapor present in our atmosphere, it is necessary that such a condition should be true; in such a case, only, is it immaterial what distribution of densities exists in the atmospheric strata.

Janssen[1] finds, however, that certain oxygen bands do not satisfy this condition; neither does carbonic acid gas, according to Ångström.[2] Consequently it is important to find whether or not the absorption due to water vapor is expressed by Bouguer's formula in its ordinary form.

[1] J. Janssen, *Report British Association for Advancement of Science*, Bath, p. 547, 1880.

[2] Knut Ångström, *Annalen der Physik*, Band 6, p. 163, 1901. Somewhat analogous variations are observed with some salt solutions. See E. Müller, *Annalen der Physik*, Band 12, p. 767, 1903.

INTRODUCTION

The region of the solar spectrum observed at the Smithsonian Astrophysical Observatory, under the direction of Mr. Langley, is particularly adapted to this study of the spectroscopic absorption of atmospheric water vapor between wavelengths 0.68μ and 2.0μ. At the time of the publication of the first volume of the *Annals* of this Observatory, although some attempts had been made at quantitative measures in the atmospheric bands and other places in this region of the solar spectrum, the results were very meager.[1] The bolograms then taken, made for the determination of the deviations and wavelengths of the various absorption lines and bands, were not adapted to measures of the ordinates or intensities. The plates were taken at insufficient speed, and no determinations of the zero of ordinates were made except at the beginning and the end of an hour's run. A subsequent trial proved but little more fertile.

Within the last two years, in the bolographic study of the general atmospheric absorption[2] and the solar constant of radiation, bolograms have been taken at twenty times the speed formerly employed, and the zero of ordinates is now determined nearly every minute during the run. Moreover, owing to the improved bolometric apparatus, the drift has been reduced to such an extent that no more now may occur in a week than formerly often occurred in an hour. Consequently these recent bolograms are far better suited to the present discussion of the ordinates, although unfortunately the effective dispersion used is much too small for the best results.

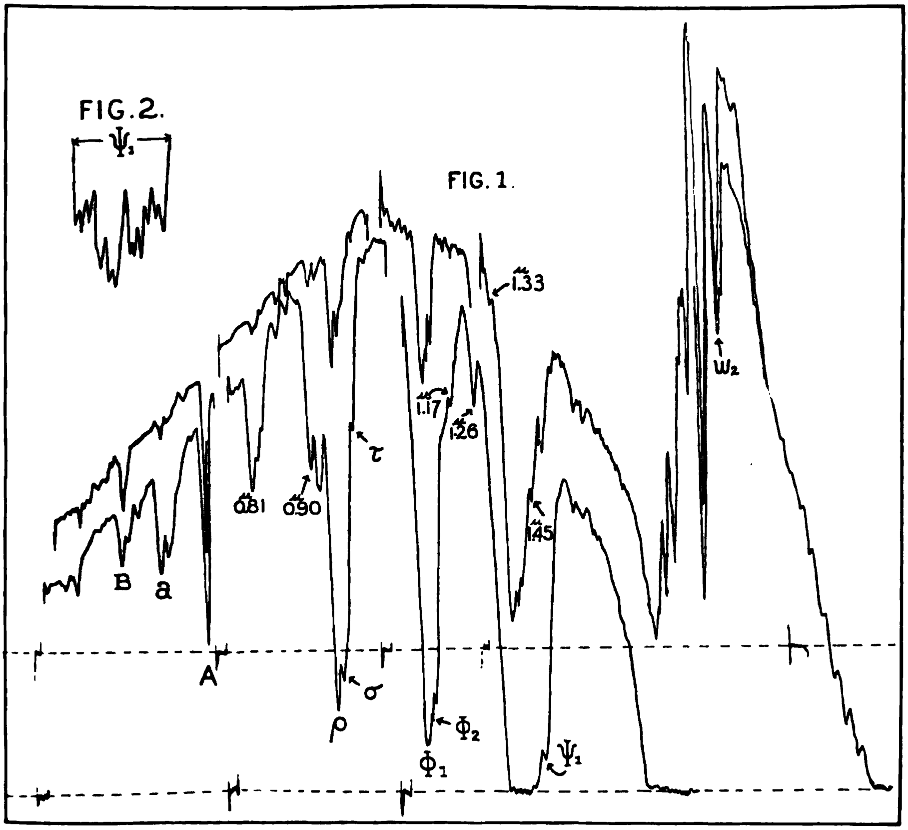
This paper, then, is devoted to the application of Bouguer's formula to measures of the transmission of our atmosphere in the various absorption bands between B (0.687μ) and ω_2 (2.05μ). These various bands are indicated in plate I, which consists, in figure I, of two superposed bolograms, one of February 19, 1903, of very small water vapor absorption, the other of September 14, 1903, and of great water-vapor absorption. The bands may be tabulated as follows:

TABLE I

B,	atmospheric	oxygen,	wavelength	0.687μ
a,	"	water vapor,	"	0.718
A,	"	oxygen,	"	0.760

[1] Chapter VII, p. 205, vol. I, *Annals of the Astrophysical Observatory of the Smithsonian Institution,* 1900.

[2] *Smithsonian Reports* for 1902 and 1903. S. P. Langley, *Astrophysical Journal,* XVII, p. 89, 1903, and XIX, p. 305, 1904. C. G. Abbot, *Smithsonian Miscellaneous Collections (Quarterly Issue),* vol. 45, p. 74, 1903.



BOLOGRAPHIC ENERGY CURVES OF THE SOLAR SPECTRUM OF A 60° GLASS PRISM

FIG. 1. Spectrum between wavelengths 0.66 μ and 2.6 μ; (Upper curve, February 19, 1903, small water-vapor absorption; Lower curve, September 14, 1903, great water-vapor absorption). FIG. 2, Detailed structure of band Ψ_1.

—,	atmospheric	water	vapor,	wavelength	0.814
—,	"	"	"	"	0.896
ρ,	"	"	"	"	0.933
σ,	"	"	"	"	0.945
τ,	"	"	"	"	0.974
Φ_1	"	"	"	"	1.119
Φ_2	"	"	"	"	1.134
—,	"	"	"	"	1.172
—,	"	unknown absorbent,		"	1.265
—,	"	water vapor,		"	1.331
—,	"	"	"	"	1.451
Ψ_1	"	"	"	"	1.469
w_2	"	unknown absorbent,		"	2.049

That the *A* line and the deepest portion of *B* are due to atmospheric oxygen, has been shown by Egoroff.[1] A comparison of the two curves in figure I of plate I shows the presence, however, of considerable water vapor absorption in the "tail" of *B*. *a* was found by Ångström[2] to be due to water vapor. With the exception of the lines at 1.265 μ, 1.331 μ, and 2.049 μ, probably the earliest evidence of the origin of the others is in the work of Abney and Festing.[3] For the bands including $\rho\sigma\tau$ and those of shorter wavelengths, the evidence rests most directly in their variations in intensity between moist and dry days. Paschen[4] finds Ψ and Ω in the emission spectrum of water vapor. Most of the bands, including Ψ, are shown in curves for the absorption of liquid water made by Abney and Festing.[5] Moreover, the evidence for the water vapor bands (including that at 1.33μ), given in plate I, figure I, and plates IV and V, should be conclusive of their origin. This does not necessarily mean that the particular "nicks" in the curves are atmospheric; they may be due to some solar line superposed on the greater atmospheric band. By far the greater portion of the absorption must, however, be terrestrial.

BOUGUER'S FOMULA

Before proceeding with the bolographic observations in these bands, the formula by which it is hoped to express these measures of

[1] N. Egoroff, *Comptes rendus de l'Academie des sciences,* 97, p. 555, 1883; 101, p. 1143, 1885. See also A. Cornu, *Annales de chimie et de physique* (6) 7, pp. 5–105, 1886.

[2] A. Schellen, *Die Spectralanalyse,* vol. 2, p. 32.

[3] Capt. Abney and Col. Festing, *Proceedings Royal Society of London,* 35, p. 80, 1883.

[4] F. Paschen, *Annalen der Physik und Chemie,* 52, p. 226, 1894.

[5] Abney and Festing, op. cit., p. 333.

atmospheric transmission should first be considered. Bouguer's formula in a somewhat modified form may be written—

$$e = kd = e_0 a^{m\delta \frac{\beta}{\beta_0}} \qquad (1)$$

where e is the amount of energy of a particular wavelength as received after its passage through the atmosphere. It is equal to the deflection, d, of the galvanometer, multiplied by a constant, k, a function of the receiving apparatus.

e_0 is the amount of this energy which would have been received had there been no terrestrial absorbing medium in the path of the rays.

a, the coefficient of atmospheric transmission, is equivalent to the fractional amount of energy transmitted by a unit layer. The unit layer of water vapor is taken to be such that, if condensed into a stratum of liquid water of the same cross-section, it would be one centimeter thick.

m, the air mass, is the length of the path of the ray through the earth's atmosphere. The unit "an atmosphere" is the length of the path with the sun in the zenith.[1]

$\frac{\beta}{\beta_0}$ is the ratio of the observed barometer β to the standard height $\beta_0 = 760$ mm. As the variations in β have not amounted to more than one percent, this factor has been neglected.[2]

---

[1] $m = \frac{\text{Refraction}}{58''.36 \times \text{sin. zenith distance}}$; James D. Forbes, *Philosophical Transactions of the Royal Society of London*, 1842, part I, p. 225.

[2] This barometric term is, however, very misleading. The terrestrial atmosphere produces at least three kinds of absorption, due respectively to dust, to the permanent gases, and to the fluctuating vapors. It seems improbable that absorption due to the dust above a station varies with the barometer as indicated by the formula, for taking in illustration an extreme case of a cyclonic low barometer, the correction would imply less absorption, whereas the ascending currents may carry the dust into the upper and purer stata of the air, while the incoming currents at the bottom bring in additional dust, so that the absorption is actually increased. In ascending from one station to another at a higher altitude, the factor again affords no correct indication of the decrease of the absorption due to dust, unless indeed the decrease of barometric pressure follows the same law as the decrease in dust contents. In the second case of the absorption of the permanent gases of the atmosphere, the use of the barometric pressure seems legitimate for observations at a single station; for stations at different altitudes the partial pressure due to the gas causing the absorption should be used. Water vapor is an example of the third kind of absorbent, and a special factor for its transmission is introduced in the formula.

δ equals the amount of water vapor in the atmosphere. It is tentatively determined according to a formula given by Hann,[1] where $\delta = \varepsilon_0$ (.23); ε_0 is the vapor pressure, in centimeters, at the surface of the earth, as deduced from readings of the wet and dry thermometers. Unfortunately water vapor measures were not taken during the times of taking these bolograms, originally made for a purpose not requiring such measures, and it has been necessary to use in place of contemporary data, observations taken at 8 P. M., and kindly furnished by Mr. Willis L. Moore, Chief of the United States Weather Bureau.[2]

Bouguer's formula in its logarithmic form,

$$\log d = \log \frac{e_0}{k} + m\delta \log a, \qquad (2)$$

with log d and m as variables, is used in plates II and III, shortly to be described; but in plates IV and V the formula has been further modified, as follows: The fractional transmission due to the water vapor alone, apart from the dust of the air, has been used in place of kd, so that, assuming all the absorbing vapor to be terrestrial, e_0 becomes unity and we have, calling D this fractional transmission,

[1] Dr. Julius Hann, *Lehrbuch der Meteorologie*, Leipzig, 1901, p. 225.

[2] These, with other data incident to the bolograms, are tabulated below (Table II); the second column gives the range of air masses between which observations were used. In the last column the condition of sky is given; 1 being as good as possible, 3 would be useless for observation:

TABLE II

Date.	Air-Masses.	Thermometer. Wet.	Thermometer. Dry.	Barometer.	Water vapor in one atmosphere.	Remarks.
1902		°	°	in.	cm.	
Sept. 11	1.2 to 2.2	60.1 F	69 F	30.0	2.46	Sky 1, calm, then light S. W. winds, cirri.
Oct. 2	1.6 to 2 6	57.9	62	30.0	2.54	Sky 1, calm.
15	1.6 to 4.2	47.0	53	29.9	1.50	Sky 1.
16	1.4 to 3.1	53.8	56	29.9	2.28	Sky 1–2, calm.
22	1.6 to 3.6	45.5	50	30.1	1.49	Sky 1, calm, cold.
Nov. 15	1.9 to 5.7	60.0	68	30.0	2.51	Sky 1–2, warm.
1903						
Feb. 19	1.6 to 3.1	14.0	15	30.5	0.39	Sky 1–2, cold, cloudless all day.
Mar. 3	1.5 to 2.4	39.8	46	30.4	1.03	Sky 1.
25	1.4 to 3.4	39.0	44	30.0	1.06	Many cumuli, N. W. wind.
26	1.2 to 3.4	46.0	53	30.1	1.36	Sky whitish but fine, N. W. wind.
Apr. 17	1.5 to 2.3	49.5	56	29.7	1.65	Sky whitish, many cumuli.
28	1.1 to 2.5	56.0	70	30.1	1.71	Sky 1, calm; light S. W. wind at end
29	1.1 to 2.3	62.0	77	30.0	2.27	Sky 1, milky blue.
Dec. 23	2.2 to 3.4	33.5	39	30.3	0.76	Sky clearest since long time.

$$D = a^{m\delta} \tag{3}$$

or

$$\log D = m\delta \log a \tag{4}$$

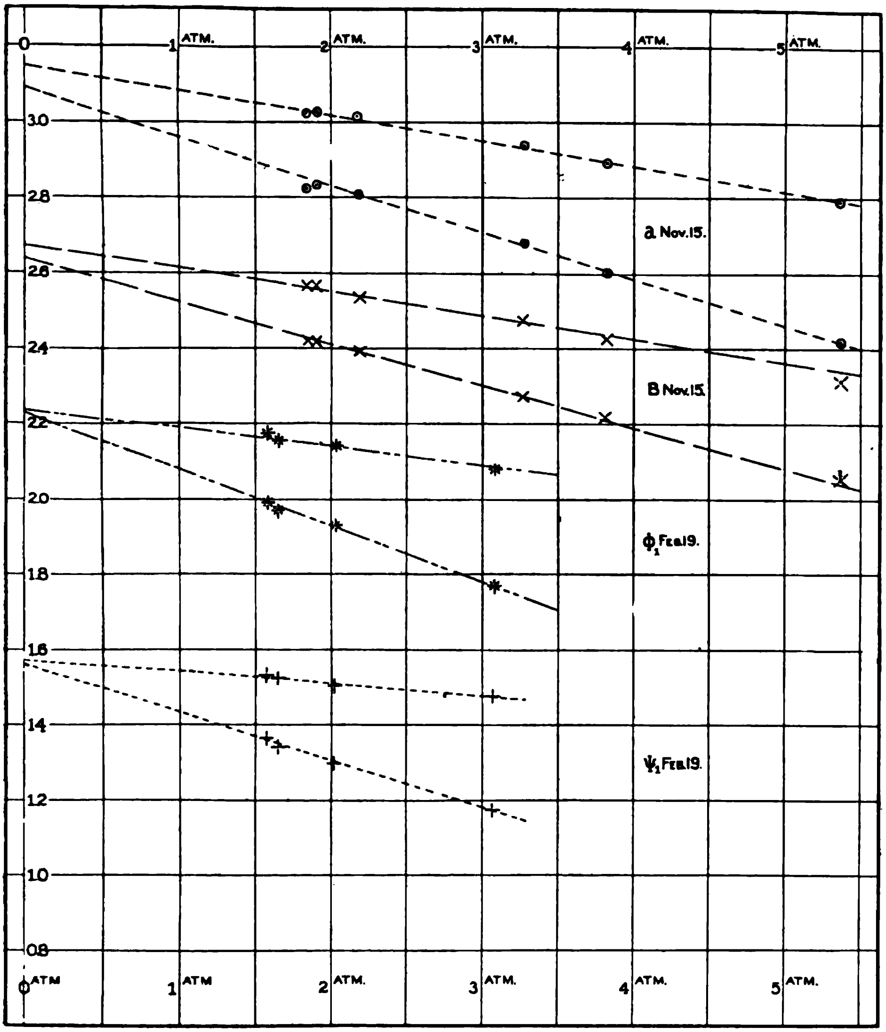
log D and δ being then used as the variables. The values of a in equations (2) and (4) are not identical but are related as indicated in equations (5) and (6) below.

FIRST METHOD OF DETERMINING THE TRANSMISSION COEFFICIENT

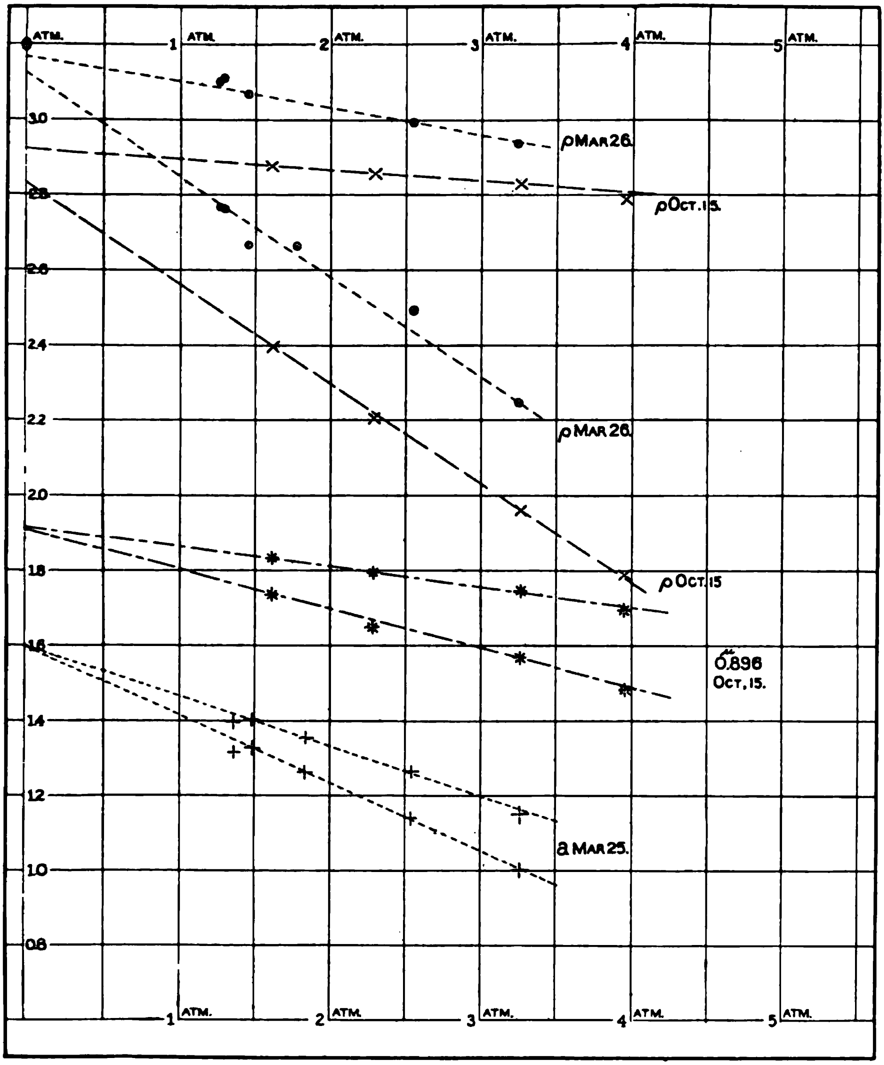
The treatment of the observations for finding the transmission coefficient of water vapor may thus follow two independent procedures. In the first method the sun is observed at various altitudes on the same day, thus altering the amount of the absorbent by changing the length of the path of the beam through it, while the density, δ, of the absorbent remains constant. The effect of diminishing proportionately the path of the ray in every one of the horizontal layers of the earth's atmosphere containing the absorbing medium is thus followed, and from the knowledge so gained it may be possible to pass by extrapolation to the case where each layer is zero and there is no absorption. In the case of high and low sun measures at a single station, the exact vertical distribution of the absorbent is immaterial to the legitimacy of Bouguer's formula, provided the distribution is constant during the observations, and uniform, at equal altitudes, over moderate horizontal air layers. The unit layer of water vapor would have the same distribution of density that exists in the actual vertical atmospheric column.

It may be objected that the water vapor in the air is too fluctuating for any such treatment, yet it seems from the spectroscopic evidence, which follows, that there are days when conditions are fairly constant, seldom during the morning hours, but more often during afternoon. Oftentimes a month may pass without such days in this locality.

In plates II and III are shown some of the data plotted according to this method. The abscissæ are "atmospheres" and the ordinates the logarithms of the galvanometer deflections. These plots, according to Bouguer's formula, should be linear, and generally are so. A still further test, however, may be applied. For each date and wavelength two series of points are plotted. The lower points correspond to the ordinates at the bottom of the deflections, the upper to the smooth curves drawn across the tops of the bands, representing what the ordinates would have been had there been no absorption from the gas or vapor under consideration. If the absorption were



DETERMINATION OF TRANSMISSION COEFFICIENTS OF ATMOSPHERIC WATER VAPOR BY CHANGING LENGTH OF PATH IN THE ABSORBING MEDIUM



DETERMINATION OF TRANSMISSION COEFFICIENTS OF ATMOSPHERIC WATER VAPOR BY CHANGING LENGTH OF PATH IN THE ABSORBING MEDIUM

solely terrestrial, the two lines thus determined should intersect on the line of zero atmospheres.[1]

This condition is probably as well fulfilled as can be expected, considering the impurity of the spectrum. Probably the upper line of each pair suffers little in its accuracy from this impurity; but as to the lower line—the small dispersion, the slit width, the bolometer width, the time of swing of the galvanometer needle, the speed with which the spectrum is passed over the bolometer,[2] and the composite character of the lines all tend to make the deflections too great. Figure 2, plate I, shows the composite character of Ψ_1 as shown in detail bolograms of 1898; and this may be compared with the same band in figure I under the present conditions. Moreover the greater the absorption in the band, the more it is influenced by these conditions, and all tend to make the bolographic ordinate at the bottom too great, and to cause the lower line of each pair in the plots to reach the line of zero atmospheres below the upper line. For days and lines of very great absorption, the deflection becomes so small in some of the greater bands that the error from the uncertainty of the zero is an important additional factor.

However, despite these limitations, as shown in plates II and III, extrapolations to without the earth's atmosphere have filled up the bands as follows:

TABLE III

Date	Band.	Ratio of Ordinate of Band to that of Smoothed Curve.([3])	
		At Earth's Surface. Air Mass = 2 Atmospheres.	Outside Atmosphere. Air Mass = 0 Atmospheres.
November 15, 1902.	a	0.65	0.90
" " "	B	0.71	0.93
February 19, 1903.	Φ_1	0.61	0.99
" " "	Ψ_1	0.62	0.98
October 15, 1902.	ρ	0.27	0.81
" " "	0.896μ	0.77	0.99
March 25, 1903.	a	0.80	1.00
" 26, "	ρ	0.35	0.90

[1] The absorption, however, may not be solely terrestrial on account of the possible superposition of some solar line as previously indicated. The depth of some solar lines is quite great. The ratio of the energy at the bottom of the *C* line to that indicated by a smooth curve across its top, is certainly less than 0.70. For the *H* and *K* lines it is certainly less than 0.15.

[2] The difference of deviation from *A* to ω_2 was 130′; the slit width subtended from 10″ to 15″, the bolometer width 16″; the spectrum passed over the bolometer at a speed of 20′ in one minute of time; and the time of a single swing of the galvanometer needle was about 1½ seconds. No correction has been made for these.

[3] See also similar data in columns five and six of Table IV.

It should not be inferred from this table that the values of the solar radiation outside the atmosphere, determined here, are too low. In solar constant determinations the smoothed curve alone is used, and, as just indicated, the deficiency in plates II and III is probably nearly wholly due to the errors of observations in the bands.

The determinations of the transmission coefficients by this method are tabulated in the next section.

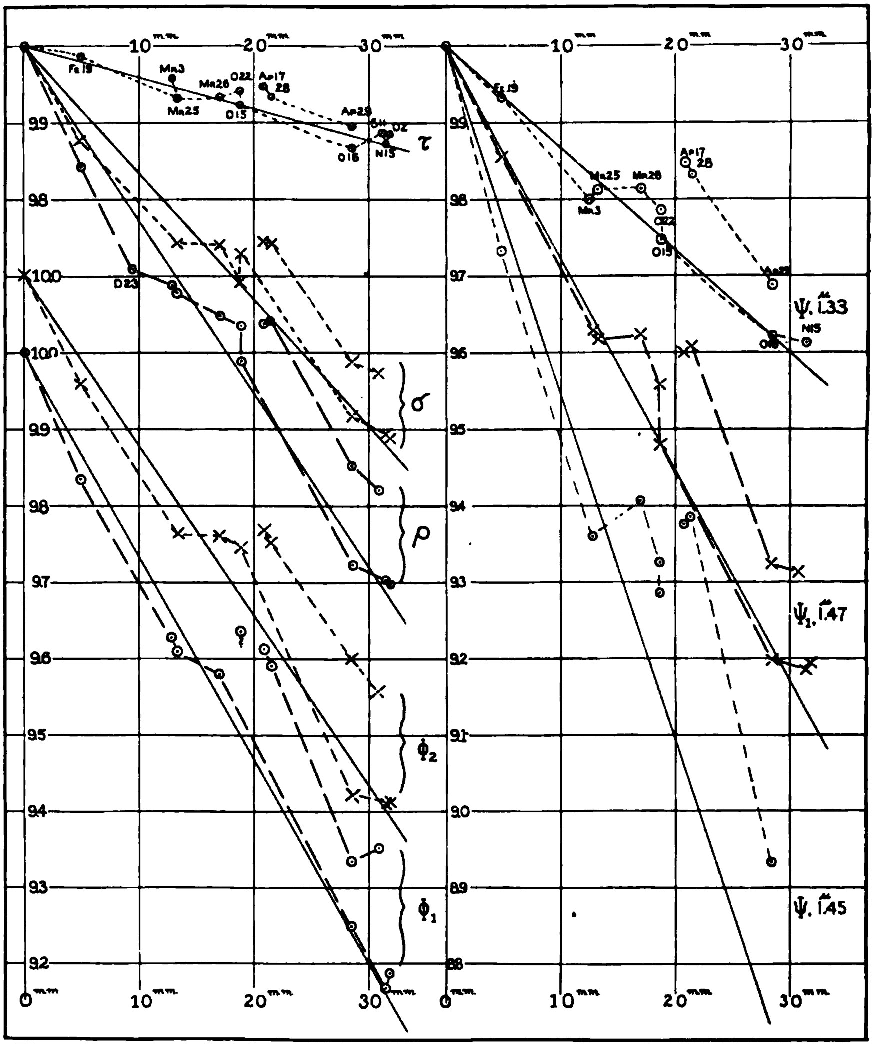
SECOND METHOD OF DETERMINING THE TRANSMISSION COEFFICIENT

The second method of applying and testing the formula is to observe the sun at the same altitude or air mass on days of different densities, δ, of water vapor. Since it has been impracticable to observe the sun always at such a standard altitude or air mass, which in the present discussion has been taken as one and one-quarter atmospheres, the observations have required a small correction by means of Bouguer's formula, in order to reduce them to this standard air mass. The corrections, in general, have been small. The observations, reduced according to this second method, are plotted in plates IV and V, where the abscissæ are the equivalent layers of water vapor present in the path of the beam, and the ordinates the logarithms of the fractional transmission. As these observations have been taken with a comparatively high sun, they are not so much subject to the sources of error mentioned in the previous section, although without doubt they are still affected by them.

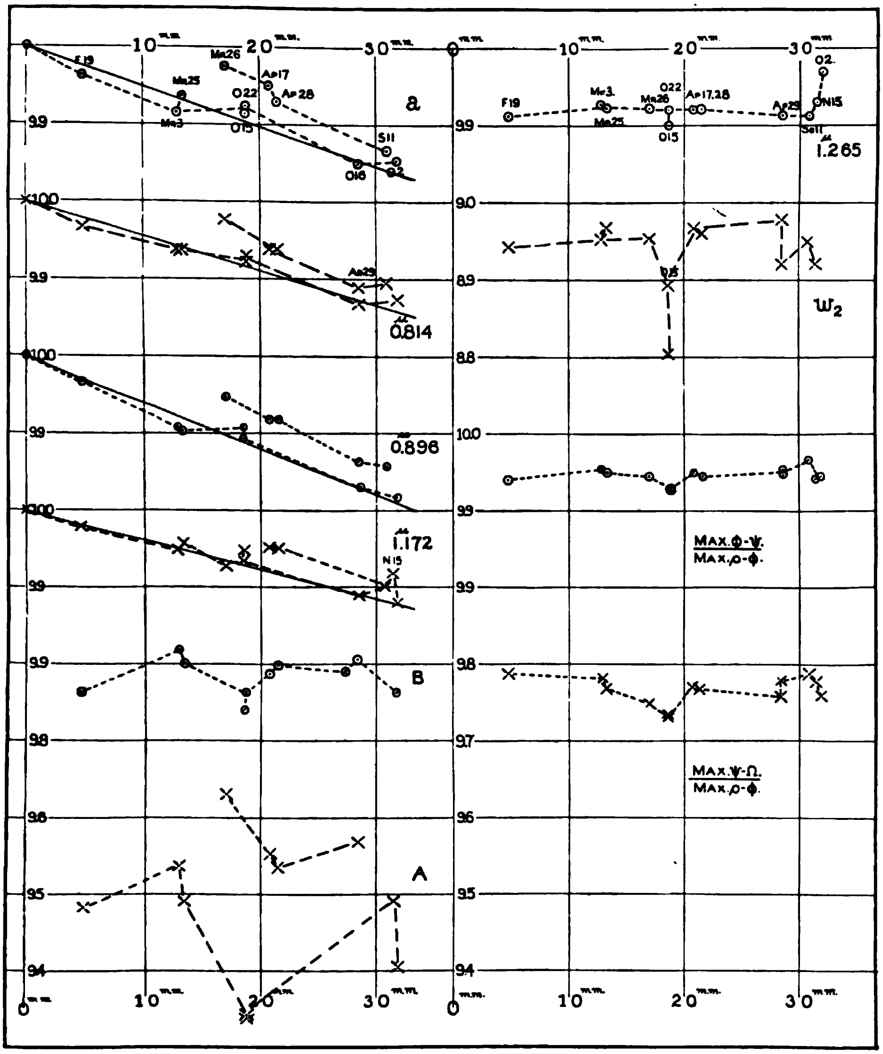
The observations seem to conform remarkably well with the formula, if we except the group including April 17, 28, 29, and September 11. It may be seen from Table II, that on April 17 there were many cumuli; on April 28 a change in the wind during the latter part of the observation; and on September 11 there were many cirri. The constants of the apparatus might have been different on those days, rendering the purity of the spectrum less, but although the appearance of the plot for the very deep and narrow *A* line may seem to support this view, that of ω_2 does not. Possibly during the months of increasing water vapor in the atmosphere there is some lag of the upper air in conforming with Hann's equation for the amount of water vapor present. In drawing the straight line representing the data, this discordant group has been neglected.

TRANSMISSION COEFFICIENTS

The value of the transmission coefficient a, of one centimeter of liquid water in vapor form, may be determined in two ways: First, referring to plates II and III, if a_1 is the transmission coefficient ob-



DETERMINATION OF TRANSMISSION COEFFICIENTS OF ATMOSPHERIC WATER VAPOR BY CHANGING DENSITY OF ABSORBENT



DETERMINATION OF TRANSMISSION COEFFICIENTS OF ATMOSPHERIC WATER VAPOR BY CHANGING DENSITY OF ABSORBENT

tained from the upper line of a pair, a_2 that corresponding to the lower, and a the coefficient for the water vapor alone, then

$$\log a = \left(\log \frac{a_1}{a_2}\right) \div \delta \qquad (5)$$

And in the second place, referring to plates IV and V,

$$\log a = \frac{\log A}{m\delta} \qquad (6)$$

The values of these transmission coefficients for the various water vapor bands are exhibited in the following table:

TABLE IV

Band.	Wave-length.	Transmission Coefficient. Second Method Density of Vapor Varying.	Transmission Coefficient. First Method Length of Absorbing Stratum Varying.	Continuation of Columns 3 and 4 of Table III.		Date for Last Three Columns.
a	0.718μ	0.889	0.94	0.65	0.90	Nov. 15, 1902
			0.90	0.80	1.00	Mar. 25, 1903
—	0.814	0.902	0.91	0.66	0.99	Oct. 16, 1902
			0.92	0.83	0.99	Mar. 25, 1903
			0.92	0.69	0.95	Apr. 29, 1903
			0.93	0.80	0.99	Apr. 17, 1903
—	0.896	0.871	0.87	0.90	1.00	Feb. 19, 1903
			0.92	0.65	0.99	Apr. 17, 1903
			0.92	0.62	0.95	Apr. 29, 1903
ρ	0.933	0.594	0.62	0.37	0.98	Mar. 3, 1903
			0.61	0.10	0.91	Oct. 16, 1902
			0.65	0.13	0.91	Apr. 29, 1903
			0.71	0.32	0.93	Apr. 17, 1903
σ	0.945	0.683	0.69	0.18	1.00	Oct. 16, 1902
τ	0.974	0.909	0.91	0.64	0.97	Oct. 16, 1602
Φ_1	1.119	0.541	0.54	0.61	0.99	Feb. 19, 1903
			0.53	0.06	1.02	Oct. 16, 1902
			0.56	0.30	1.00	Mar. 3, 1903
Φ_2	1.134	0.599				
—	1 172	0.916				
Ψ	1.331	0.736				
Ψ	1.451	0.355				
Ψ_1	1.469	0.529	0.55	0.62	0.98	Feb. 19, 1903
			0.55	0.06	0.95	Oct. 16, 1903
			0.59	0.08	0.80	Apr. 29, 1903

The fifth and sixth columns are continuations of the last two columns of Table III. Column five indicates the amount of radiation transmitted in the band at an air mass of two atmospheres, expressed as a fraction of the amount which would be found if there were no water vapor absorption. Extrapolating to zero both from the band and from the smoothed curve over the band, as in plates II and III, it may be found how nearly the band is obliterated outside the atmosphere by employing Bouguer's formula. The absorption still remaining is indicated by the difference between the transmission so found as given in the sixth column, and unity. As would be expected from the sources of error indicated in discussing the first method of obtaining the transmission coefficients, the value of the coefficient obtained by varying the air mass, *m*, is generally greater than that obtained by varying the density, δ, of the water vapor.

Several reductions with the air mass, *m*, varying are included in the table for April 17 and 29 of the discordant group of days previously mentioned. It will be observed that the difference between the values in the third and fourth columns is here greater than usual. Now, assuming that the values of the transmission coefficients of these different bands obtained from the observations of all the days but those of the discordant group by varying the density are correct, these values (a) and the corresponding values of a_1 and a_2 may be substituted in equation 5, page 9, to determine new values of δ for the days in question. These, reduced to an air-mass of 1.25 atmospheres for comparison with plates IV and V, are:

April 17, 1903,	1.31,	1.24,	1.36,	mean 1.30
April 29, 1903,	2.41,	2.41,	1.94,	mean 2.25

If these values had been used for the corresponding points in plates IV and V, the data for these dates would not then have been discordant.

In plate V are plotted the values for the transmission for the bands *B* and *A*, due to oxygen, and for the bands at 1.285 μ and ω_2, of unknown atmospheric origin. There are also plotted the ratios of the ordinates at the maxima between Φ and Ψ, and between Ψ and Ω, to those between ρ and Φ. All of these plots are apparently independent of water vapor. It is improbable that any conclusion can be drawn as to the origin of the bands at 1.285 μ and ω_2 from comparison with the plots for the oxygen bands. The irregularities in *A* are probably due to its great depth and narrowness, so that the ordinate at its bottom depends very greatly on the instrumental conditions.

RELATION OF ABSORPTION TO DENSITY OF ABSORBENT

Very little is yet known of the change of absorption of a vapor in passing to the liquid form, except from measures of the total absorption over the whole spectrum. Those oxygen bands which have an absorption varying with the square of the density, still seem to follow the same law when the absorbent is in liquid form.[1] Saturated steam, according to Very,[2] exercises more total absorption over the whole spectrum than the same amount of water vapor under atmospheric conditions. Water in liquid form goes still further in this direction. "A layer of water 40 centimeters thick is almost absolutely impervious to solar infra-red radiation beyond the wave-length 1.0μ. No such absorption occurs with the moist humid air as the sun approaches the horizon, although the absolute amount of water in a vaporous form interposed in the path of the rays must be even greater than that contained in a layer 40 cm. thick."

However, Paschen says: "In the liquid state there is a continuous general absorption, whereas in the gaseous form only a discontinuous absorption and emission spectrum is found, there being no indication of a continuous superposed absorption or emission." It may be very possible that the selective absorption in these water vapor bands follows the same law of density when the absorbent is in liquid form, and that the general absorption causes the great increase in opacity observed. The last two curves in plate V certainly show no differential effect between the maxima from ρ to Φ, Φ to Ψ, and Φ to Ω, due to a general water vapor absorption. It is hoped to discuss this point further in a subsequent paper.

Probably the only available measures on the absorption of liquid water, comparable with those on water vapor, contained in this paper, are those made by Abney and Festing.[4] Their results give, with layers of ½ inch and 1¾ inches liquid water respectively, in ρ, 78 and 19 percent transmitted, and for Φ, 69 and 2 percent. The logarithms of these numbers are 9.89, 9.28, 9.84, and 8.30, respectively. The first three lie above, the last below the lines indicating the absorption of aqueous vapor in plate II. However, little weight can probably be attached to the comparison, on account of the probable difference in the effective purity of the spectroscopes used.

SUMMARY

The selective absorption of water vapor within the range of densities observed seems to depend only on the amount of the

[1] J. Janssen, *Report British Association for Advancement of Science*, Bath, p. 547, 1880. G. D. Liveing and Dewar, *Philosophical Magazine* (5) 40, p. 268, 1895.

[2] F. W. Very, *Bulletin G, U. S. Weather Bureau*, p. 94, Washington, 1900. Ångström finds the general absorption of CO_2 increases more rapidly than with the first power of the density. Knut Ångström, *Annalen der Physik*, Band 6, p. 163, 1901.

[3] *Annalen der Physik und Chemie* 52, p. 221, 1904.

[4] *Proceedings Royal Society of London*, 35, p. 328, 1883.

absorbent present, and is well expressed by Bouguer's formula. In other words, the absorption produced by a given quantity of water in the form of vapor is the same whether the path is great through a small density or vice-versa. Considering successive bands, for example 0.81 μ, $\rho\sigma\tau$, Φ, Ψ, Ω, it may be noted that the selective absorption of water vapor is not greatest, like the general absorption, at the shorter wavelengths, but increases as the wavelengths of the bands increase. It varies from 10 percent in the more shallow bands near *A*, at 0.76 μ, to nearly 100 percent in the bottom of Ω at 1.80 μ, where only on exceedingly dry days is much indication of energy detected.

However, in the separate bands themselves, where the increase in absorption on reaching the bands from the shorter wavelength side is quite sudden, the absorption then more slowly decreases, like the general absorption, with increasing wavelength.

The best values for the transmission coefficients are those in the third column of Table IV. They give the fractional amount of the incident energy transmitted by a layer of water 1 cm. thick in the form of vapor.

No indication of a general water vapor absorption in the region from 0.68 μ to 2.00 μ has been found.

A NEW ASHMUNELLA FROM NEW MEXICO

By PAUL BARTSCH

Some time ago the United States National Museum received two specimens of Ashmunella which represent an undescribed species. The shells were collected by Mr. C. H. T. Townsend on the slopes of the ridge on the south fork of Ruidoso river, about five miles above the town of Ruidoso, at an altitude of 8,500 feet. Ruidoso is in the Sierra Blanca, Mescalero Apache Indian reservation, Lincoln county, New Mexico.

ASHMUNELLA TOWNSENDI new species

Shell moderately elevated, rather thin, axially strongly ribbed, and closely spirally incised, pale brown to bluish-white.

The shell examined under a compound microscope shows three distinct developmental stages. The first or nepionic consists of one and three-quarter well-rounded volutions, the earliest portion of which shows faint traces of obscure axial lirations which are gradually replaced by rather distant, interrupted, feebly papillose axial liræ, the liræ and papillæ becoming stronger and more crowded as the shell advances in age. Near the terminus of the nepionic stage several strong, very oblique, posteriorly slanting folds make their appearance and the finer sculpture becomes again enfeebled. The second or neanic stage consists of about one and one-fourth well-rounded turns, and is marked by many closely placed axial lirations which are somewhat stronger and a little more distantly placed in the beginning than in the latter portion of this stage. There are faint papillæ present which are irregularly scattered and appear indifferently on the liræ or interliral spaces. The entire neanic portion is also marked by very fine, closely-placed, wavy spiral lines. The third or ephebic stage consists of two and one-third volutions, the last one of which shows a tendency toward peripheral keeling. The whorls are marked by many strong, sublamellar, axial ribs which have their posterior slopes much shorter than the anterior. These ribs pass undiminished from the summit of the whorls over the periphery into the moderately wide umbilicus. The entire ephebic portion is marked by many subequally spaced, strongly incised, spiral lines, which appear somewhat more closely spaced on the base than between the sutures. The last whorl is deflected near the aperture and is decidedly constricted behind the strong peristome. Aperture rather small, decidedly oblique, subcircular, slightly taller than wide; outer lip with a broad, thickened, strongly reflected, white peristome which bears a low, moderately broad tubercle on the inner border of the basal wall; parietal wall covered by a thin transparent callus bearing a weak elongated tubercle on its middle, the attenuated end of which points downward to the junction of the columella and the parietal wall.

The specimens are numbered 152,953, U. S. N. M. The type measures: Height, 8.2 mm.; long diameter, 15 mm.; short diameter, 13.3 mm. Aperture: Outside measurements: width 7 mm.; height, 7.3 mm.; Inside measurements: width, 5.3 mm.; height, 5 mm., width of umbilicus, 2.3 mm.

The second specimen agrees in every way with the type. It is a dead specimen and appears uniformly bluish-white.

Ashmunella townsendi is most nearly related to *A. rhyssa* DALL, but is much smaller than that form and is uniformly more strongly sculptured.

A REVISION OF THE PALEOZOIC BRYOZOA

By E. O. ULRICH and R. S. BASSLER

Part II.—On Genera and Species of Trepostomata

We have no reason for emending the definition of the order Trepostomata as given in previous works by the senior author. In order to save repetition it is to be understood that, when no remarks follow a family or generic name, we are satisfied with the diagnosis given in the English edition of Zittel's *Textbook of Palæontology* or in the *Synopsis of American Fossil Bryozoa.*[1]

The classificatory value of the structure of the walls separating neighboring zooids, especially the degree in which the calcareous investment of adjoining zooids is either amalgamated or maintains for each its integrity, continues to impress us more and more favorably. According as the walls are amalgamated or retain their duplex character, the seven families recognized under the Trepostomata in the latest classification of Paleozoic Bryozoa, fall four into the first and three into the second division, as follows: (1) (Amalgamata) *Monticuliporidæ, Heterotrypidæ, Constellariidæ,* and *Batostomellidæ;* (2) (Integrata) *Amplexoporidæ, Calloporidæ,* and *Trematoporidæ.*

Division I.—*AMALGAMATA* new division

Trepostomata in which the boundaries of adjacent zoœcia are obscured by the more or less complete amalgamation of their walls.

In a few genera, notably *Prasopora* and *Aspidopora,* referred to families of this division, the amalgamation of the walls is sometimes difficult to establish.

Family MONTICULIPORIDÆ Nicholson (Emend. Ulrich)

Genus Monticulipora D'Orbigny

Our revised conception of *Monticulipora* is essentially as that published in volume III of the *Paleontology of Minnesota.* However, a few forms previously referred to the genus, principally because there was no other group to receive them, are here removed to the new genus *Orbignyella.* The peculiar granulose walls, the very

[1] *Bull. U. S. Geological Survey,* No. 173.

slight development or total absence of the laminated secondary deposit, and the presence of cystiphragms in both the axial and peripheral regions, are the principal diagnostic characters of *Monticulipora* as now understood by us. Our reasons for distinguishing the new generic group *Orbignyella* will be found under the discussion of that genus.

Through the kindness of Dr. M. Boule of the Museum d'Histoire Naturelle, Paris, we have recently procured a fragment of the specimen upon which D'Orbigny based his description of *Monticulipora mammulata,* the first of the four species and the accepted type of the genus *Monticulipora* established by him at the same time. The fragment received from Dr. Boule was carefully sectioned, and the internal characters of the species drawn by Mr. Bassler. The reproductions of these drawings on plate VI, 1–3, though adding nothing to the present knowledge, nevertheless serve to fix the status of the genus and species. They show further that Ulrich's interpretation of the species in 1882[1] was correct and that the synonymy given then by that author and later by Nickles and Bassler[2] is also correct.

The principal features of the genus are the peculiar granulose wall structure and the presence of cystiphragms in both axial and peripheral regions. The range of variation in mode of growth and mature form of the zoarium, from incrusting sheets to irregular or globular masses, and from frondescent to quite regularly ramose forms, as exhibited in the species referred to the genus by Ulrich, is still considered as properly embraced within the limits of a single genus.

The following species are characteristic middle Richmond forms, the first being the only ramose *Monticulipora* known to occur in the Cincinnatian group.

MONTICULIPORA CLEAVELANDI James

(PLATE VI, 4–6)

Monticulipora (Heterotrypa ?) cleavelandi JAMES, Paleontologist, No. 6, 1882, p. 49, pl. i, 7.

Monticulipora cleavelandi JAMES AND JAMES, Jour. Cincinnati Soc. Nat. Hist., XI, 1888, p. 15, pl. i, 4.

Monticulipora cleavelandi J. F. JAMES, Jour. Cincinnati Soc. Nat. Hist., XVIII, 1895, p. 68.

Zoarium irregularly subramose to ramose; branches subcylindrical or flattened, often 10 mm. or more in diameter. Surface smooth,

[1] *Jour. Cincinnati Soc. Nat. Hist.*, V, 1882, p. 234.

[2] *Bull. U. S. Geol. Surv.*, No. 173, 1900, p. 324.

the maculæ generally inconspicuous, but, where composed of mesopores only, quite distinct and slightly elevated. Zoœcia small, angular, with rather thick, minutely granulose walls, 8 to 9 in 2 mm. Mesopores very few and generally restricted to the maculæ. Acanthopores small and usually not showing at the surface; nor can they be readily distinguished in tangential sections from the granulose wall structure. Cystiphragms in a compact series in the peripheral region, about 3 in a distance equaling the diameter of a tube, while in the axial portion they are large and more infrequent, here varying from once to twice a tube diameter apart. Walls very thin in the axial region but becoming considerably thickened and apparently first developing their granulose character in the peripheral zone.

The only described species with which this need be compared is *M. arborea* Ulrich, a similarly ramose *Monticulipora* from the Trenton of Minnesota and Kentucky. Although agreeing closely in many respects, the absence of monticules and the smaller and less numerous acanthopores distinguish *M. cleavelandi* from the Trenton form. The occurrence of cystiphragms in both the axial and peripheral regions in *M. cleavelandi* distinguishes it from all associated Richmond bryozoans having a ramose mode of growth.

This species was supposed by us to be new, but just before this article went to press, Mr. Bassler obtained the loan of the James' types of Bryozoa from the University of Chicago and discovered the identity of our form with James' *M. cleavelandi*. Judging from the various descriptions of *M. cleavelandi,* one would never suspect that James' species and the form here described were based on the same species.

Occurrence.—James' types are from Lynchburg, Ohio. The species is very abundant in the middle division of the Richmond at Dutch creek, 4½ miles northwest of Wilmington, Ohio, and at Cowan's creek, 7 miles southwest of the same place.

Cat. Nos. 43,170, 43,171, U. S. N. M.

MONTICULIPORA EPIDERMATA new species

(Not figured)

Chætetes mammulatus QUENSTEDT (not *Monticulipora mammulata* D'ORBIGNY), Roehren und Sternkorallen, 1881, p. 75, pl. cxlvi, figs. 10, 11 (not 12).

This species is so abundant and characteristic of the middle Richmond of Ohio and Indiana and also so easily recognized by the external characters which are clearly shown in Quenstedt's figures (loc. cit.) that we think it desirable to describe its internal characters.

Unfortunately these cannot be illustrated at this time. As the species is distinct from *M. mammulata* and marks a different stratigraphic horizon, the above new name is proposed for its future designation.

M. epidermata is readily distinguished from *M. mammulata,* with which it has generally been identified by collectors, by differences in their respective methods of growth. Both are massive species, but the Richmond form grows into large flat or irregularly hemispherical masses, sometimes as much as 300 mm. in width and 150 mm. in height, and always, in the hundreds of specimens seen by us, having a more or less flattened though strongly undulated epithecated base. *M. mammulata* never attains such large proportions, and its masses are irregularly lobate or more or less rounded, instead of depressed hemispheric. Another distinction lies in the mesopores, which are more numerous in *M. epidermata.* The following description sums up the characters of this new species.

Zoarium of broad, thick, lamellate expansions or masses, sometimes reaching the dimensions mentioned above. Base always lined with an epitheca and more or less flattened and concentrically wrinkled. Surface with rather closely arranged maculæ which sometimes form sharp tubercles and again rounded monticules. Zoœcia small, rather thin-walled, angular where mesopores are less common and rounded where they are abundant; 10 to 11 zoœcia in 2 mm.

In tangential sections the zoœcial walls exhibit the usual granulose structure characteristic of the genus. Acanthopores small, rather inconspicuous, appearing more like granules. The mesopores are small, 2 or 3 usually to each zoœcium. Vertical sections show the mesopores tabulated with straight diaphragms one-half to one tube-diameter apart. Cystiphragms line the zoœcial tubes in both regions and are accompanied by a corresponding number of diaphragms.

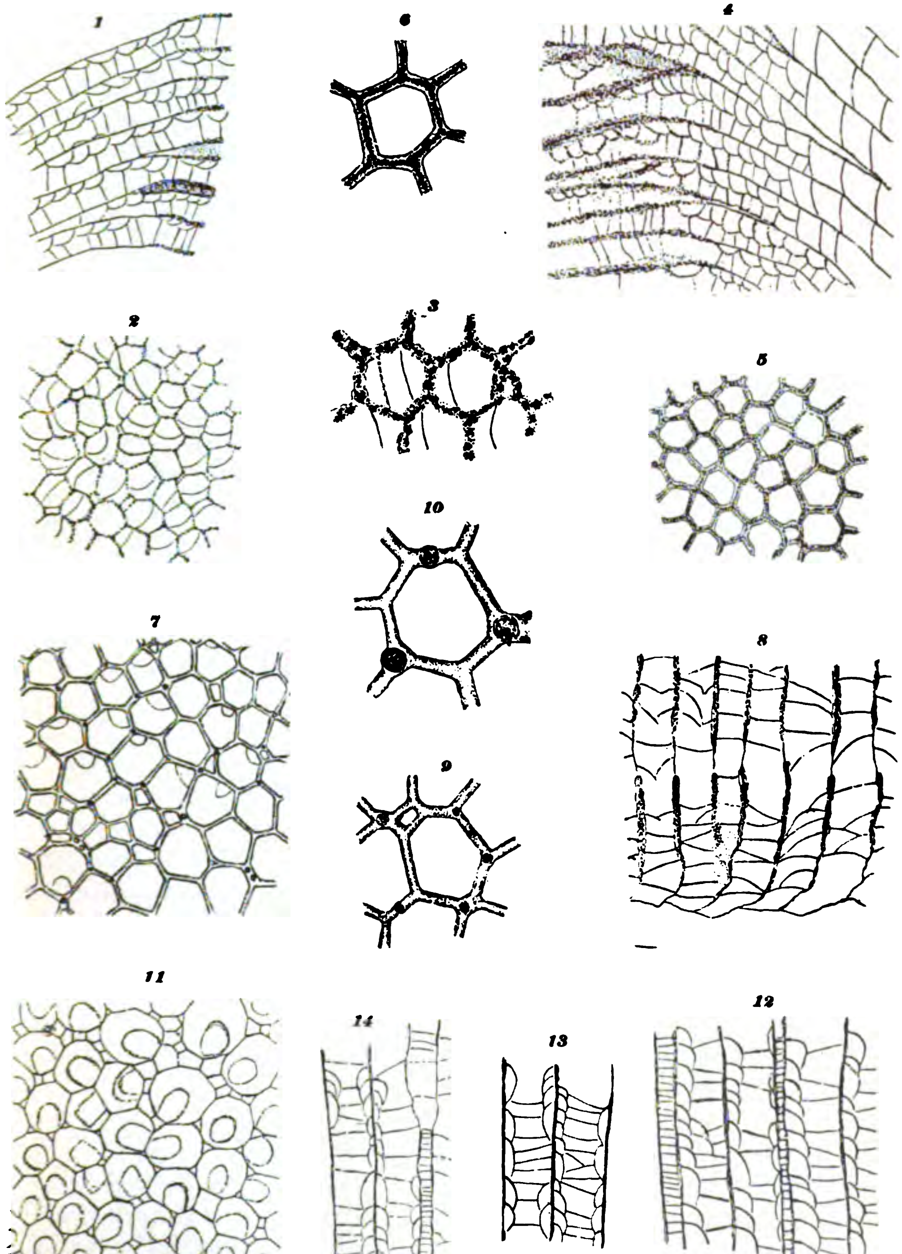
Occurrence.—Abundant in the nodular argillaceous limestones, of Middle Richmond age, exposed along Whitewater river at Richmond, Indiana. Occurs also wherever these strata are exposed at other localities in Indiana and Ohio, good specimens being found at Oxford, Ohio, particularly.

Cat. Nos. 43,172, 43,173, U. S. N. M.

Genus ORBIGNYELLA new genus

Monticulipora (pars) ULRICH, Jour. Cincinnati Soc. Nat. Hist., v, 1882, pp. 153, 232.—Geol. Surv. Illinois, VIII, 1890, pp. 370, 407.

The recent close study of all the species of *Monticulipora* has shown that, despite previous restrictions, the genus still includes



GENERA AND SPECIES OF TREPOSTOMATA

forms that do not agree strictly with the genotype; and when it was found that these doubtful species formed a reasonably distinct and apparently genetically related group, it seemed no more than serving the best interests of classification to apply a new generic term. This new genus for which we propose the name *Orbignyella,* in honor of the author of *Monticulipora,* is distinguished from the latter genus in wanting its peculiar, irregularly granulose wall structure, in having less clearly defined cystiphragms, these structures appearing more like merely curved diaphragms, and in possessing more or less well developed and sharply defined true acanthopores. The wall structure of this new genus is more like that prevailing among the *Heterotrypidæ* than the *Monticuliporidæ,* and it is only on account of curved diaphragms that we place *Orbignyella* with the latter family. At best the reference is doubtful, and the ultimate position of the genus, which should depend upon its genetic relations, may be quite different.

The following new species, *O. sublamellosa,* from the Stones River formation of Tennessee, being the most abundant form showing all the generic characters, we have adopted as the genotype. Of described species, *Monticulipora wetherbyi* and *M. lamellosa* Ulrich, of the Ordovician, are referred here with certainty, while *Chætetes expansus* Ringueberg, of the Rochester shale and *Monticulipora billingsi* Foord are doubtful members. Four or five additional, but as yet undescribed, Ordovician species are known.

Certain Devonian species now referred to *Monticulipora,* of which *M. winchelli* Ulrich is a good example, may possibly belong to *Orbignyella,* but we prefer for the present to leave them where they are, despite our conviction that they are generically distinct from *Monticulipora.* In common with practically all the known Devonian Trepostomata they have certain peculiarities that are as yet little understood and that require a special investigation before it may be deemed wise to reclassify the species.

ORBIGNYELLA SUBLAMELLOSA new species

(PLATE VI, 7–9)

Zoarium of wide lamellate expansions formed of superposed layers varying from 3 to 10 mm. in thickness; subconical masses sometimes result from the continued piling up of these layers. Maculæ not elevated but conspicuous because they are composed of aggregations of mesopores and zoœcia of larger size than the average. Zoœcial apertures small, thin-walled, 8 to 9 in 2 mm. Acanthopores small but distinct, one or two to each zooecium. Mesopores restricted almost entirely to the maculæ. Curved or oblique diaphragms very frequent, from one-half to nearly one tube-diameter apart.

This species is related to *O. wetherbyi* (Ulrich), but has smaller and less frequent acanthopores. *O. lamellosa* (Ulrich)—see plate VI, 10,—has decidedly larger zooecia besides numerous and larger acanthopores.

Occurrence.—Not uncommon in the Pierce division of the Stones River formation at Murfreesboro, Tennessee.

Cat. No. 43,174, U. S. N. M.

Genus PRASOPORA Nicholson and Etheridge

PRASOPORA PATERA new species[1]

(PLATE VI, 11–14)

Zoarium of subcircular, almost flattened disks, 30 or 40 mm. in width and usually 3 or 4 mm. thick. Under surface more or less concave, often nearly flat, covered with a concentrically wrinkled epitheca. Near the center of this face there is usually a cicatrix or the body itself (commonly a valve of *Dalmanella*) upon which growth commenced. Surface smooth, the maculæ not raised into monticules but easily distinguished by the large size of some of the zooecia contained in them.

Zooecial apertures generally appearing quite angular, the walls being thin and the mesopores small, relatively few, and, on the whole, quite inconspicuous as external features. Of the intermacular zooecia an average of 7 occurs in 2 mm. The largest in the maculæ attain a diameter nearly twice as great.

Internal structure much as in *P. simulatrix* Ulrich, but not identical. The walls are always thinner in *P. patera* and its zooecia usually more angular, while the mesopores, as a rule, are fewer in number.

Though closely related to *P. simulatrix*—a fact that was not suspected until we prepared thin sections—the discoid or saucer-shaped form so persistently maintained by the hundreds of specimens before us is so strikingly different from the nearly equally constant hemispheric or conical zoarium characterizing that species that it seems

[1] Although the purpose of these papers is to deal only with matters pertaining to the elucidation and variations of generic groups, we have found it desirable to use this opportunity for the introduction of descriptions of a few species which are characteristic fossils of certain Ordovician horizons in the Central Basin of Tennessee. Figures of the external characters of these species are given in the Columbia Tennessee folio, recently issued by the U. S. Geological Survey.

unreasonable to doubt the propriety of drawing a specific distinction between them. When the new species was first collected, we believed it would turn out to be a species of *Mesotrypa,* and possibly the same as the form described on a succeeding page as *Mesotrypa angularis.* Thin sections, however, at once proved the error of this view and at the same time supplied ample internal differences to distinguish it from all species of the latter genus.

Occurrence.—Usually very abundant in the lower part of the Hermitage formation (Safford's Orthis bed) of the Ordovician section in middle Tennessee, especially at localities in the vicinity of Columbia and northward to Nashville. The figured specimens are from an exposure about 4 miles north of Columbia.

Cat. Nos. 43,175–43,177, U. S. N. M.

Genus HOMOTRYPELLA Ulrich

We have nothing to offer that affects the standing of this genus, except to say that its usefulness in classification has been confirmed over and over again in the course of our recent studies. Although we have other equally distinct species in our collections that have never been described, the value of the one about to be described as a list fossil, and its desired use in stratigraphic work now under way, have led us to give it a place in this paper. Similar reasons have determined the matter of immediate publication for all other new species that do not modify generic definition.

HOMOTRYPELLA NODOSA new species

(PLATE VII, 1–3)

This very abundant Lorraine species is readily recognized by the closely set, sharp or rounded, often elongate monticules studding the surface of its subcylindrical, frequently dividing branches. These are often 11 mm. in diameter, though usually 1 or 2 mm. less. Under a pocket lens the entire surface appears minutely spinulose, and when closely examined it will be observed that the spines are set about the mouths of the zoœcia in such a manner that the latter are given a beautiful petaloid or rayed appearance. The zoœcia are smaller than those of other species of the genus, 10 occurring in 2 mm. The acanthopores also are small but very numerous, as many as 12 occurring around a single zoœcium.

Tangential sections show a variety of appearances according to the particular zone or zones represented in them. Sections cutting across zoœcia just beneath the surface of an old branch often exhibit no mesopores, the zoœcia being polygonal. At deeper levels mesopores can always be detected and generally become so numerous as to isolate the zoœcia. The acanthopores impart a degree of beauty to these sections to which no drawing can do justice.

Diaphragms vary from one to two tube-diameters apart in the axial region. As the tubes turn into the peripheral zone, cystiphragms are introduced, first a large one or two, then in a crowded series with three to a tube-diameter. As usual the development of cystiphragms ceases and diaphragms only are found in the more superficial portions. Mesopores numerous, closely tabulated, closing as the surface is approached.

This species is distinguished from all others of the genus by its small zoœcia, very numerous acanthopores, and closely set monticules.

Occurrence.—Abundant in the Lorraine of the Central Basin of Tennessee. The types are from the top of Mount Parnassus, at Columbia, but Negley's hill at Nashville also furnishes specimens in abundance.

Cat. Nos. 43,178, 43,179, U. S. N. M.

Genus MESOTRYPA Ulrich

The species described below, being abundant, widely distributed, and highly characteristic fossils of the Trenton, have proved valuable aids in making stratigraphic determinations.

MESOTRYPA ECHINATA new species

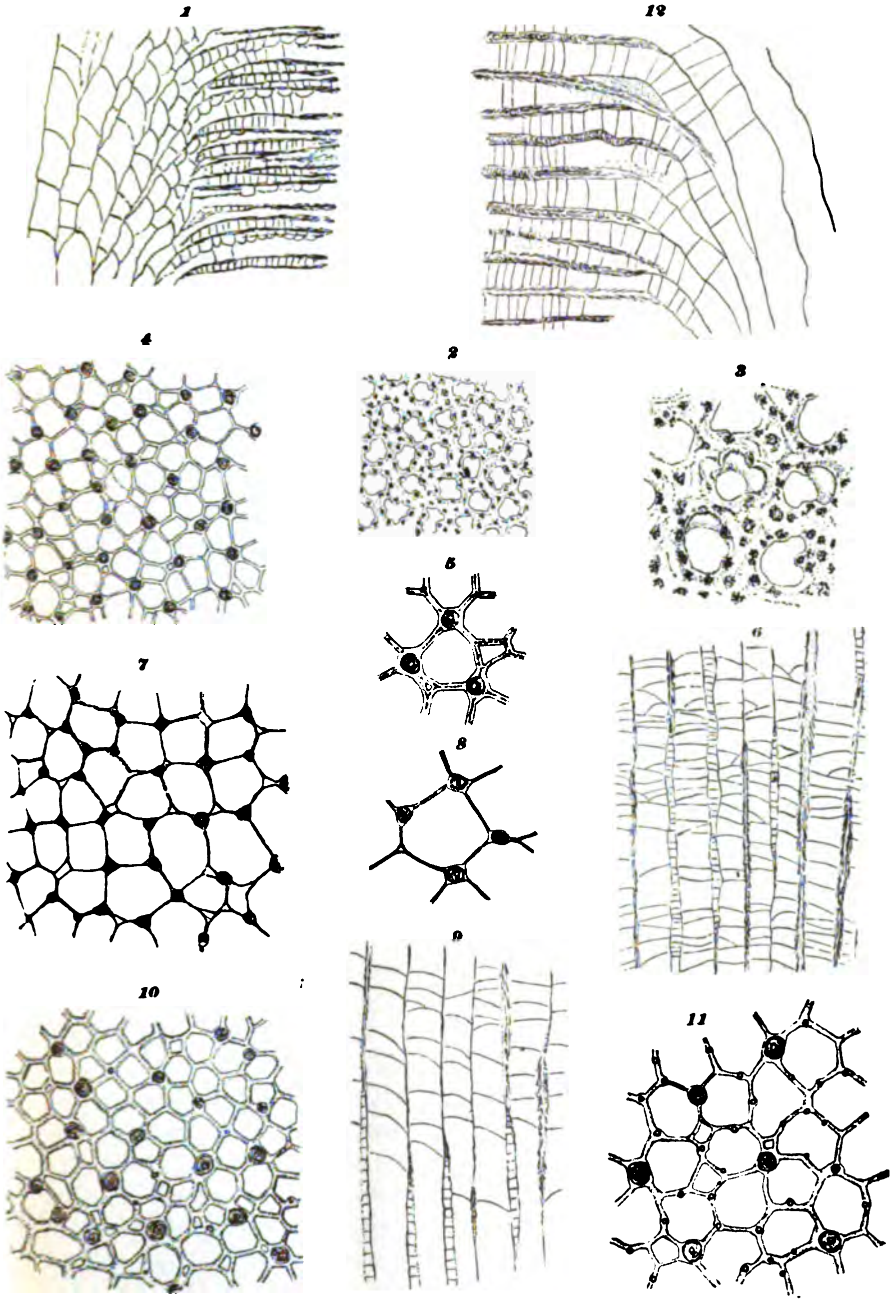
(PLATE VII, 4–6)

In this species the zoarium forms irregular, flattened, or convex disks, 5 or 6 mm. thick and sometimes as much as 50 mm. in diameter. Upper surface smooth, with inconspicuous maculæ. Zoœcia small for the genus, angular to rounded, rather thick-walled, about 8 in 2 mm. Mesopores rather numerous, irregular in size and shape. Acanthopores large, giving the surface when well preserved a spiny aspect. Diaphragm 3 to 4 in a tube-diameter in the mature zones, and more than their own diameter apart in the intermediate zones. Mesopores closely tabulated and in the usual manner.

The small zoœcia and large acanthopores are the striking features of this species. *M. infida,* the type of the genus, is very similar in certain respects, but its acanthopores are never so large and uniformly developed.

Occurrence.—Not uncommon in the Trenton at Nashville, Tennessee, and at several localities in Kentucky.

Cat. Nos. 43,180, 43,181, U. S. N. M.



GENERA AND SPECIES OF TREPOSTOMATA

MESOTRYPA ANGULARIS new species

(PLATE VII, 7–9)

Zoarium growing from discoid expansions, 3 or 4 mm. thick and 4 cm. or less in diameter, into hat-shaped forms that occasionally attain a diameter of 7 cm. and a height of 3 cm. Surface smooth but characterized by conspicuous maculæ composed of zoœcia which are often twice the diameter of the ordinary ones. Zoœcia angular, thin-walled, 6 in 2 mm. Acanthopores numerous, strong, studding the surface and very conspicuous in thin sections. Mesopores few, usually wanting at the surface and when present generally restricted to the clusters. Diaphragms curved, few in the early stages, more numerous in mature zones where two or three may be found in a tube-diameter. Mesopores comparatively numerous in the immature region, but pinch out as growth continues, closely tabulated.

The zoœcia are larger and their walls thinner, the maculæ more conspicuous, the mesopores fewer, and the acanthopores more striking than in any of the other species of the genus.

Occurrence.—Not uncommon in the shaly lower half of the Lexington limestone of the Trenton at Frankfort, Burgin, and Curdsville, Kentucky; and in the Trenton at Ottawa and Peterboro, Canada.

Cat. Nos. 43,182–43,185, U. S. N. M.

Family HETEROTRYPIDÆ Ulrich

Compared with the *Monticuliporidæ* this family is distinguished by the very general—almost total—absence of cystiphragms. Of the other families of the suborder in which the tabulation of the zoœcial tubes is by diaphragms only, the *Amplexoporidæ* are the most likely to offer difficulties in their practical discrimination.

Certain differences in their respective wall-structures have so far proved infallible and generally readily applied criteria. In the *Heterotrypidæ,* namely, the zoœcial walls have the structure specially designated as amalgamated. As seen in tangential sections of well preserved specimens, the wall separating adjacent zooids consists (1) of a moderately wide, light-colored, transversely dotted or lined, central band, which represents the amalgamated original walls, and (2), bordering it on each side, a concentrically laminated, secondary deposit. In the *Amplexoporidæ*, on the other hand, the wall, though similarly composed of two parts, differs decidedly in this, that the usually light-colored inner band is divided by a sharply defined, dark line, which represents the angular outer boundary of adjoining zoœcial tubes. The difference is regarded as fundamental, and doubtless separates the two families farther than was believed formerly.

It is a curious fact that in all essential respects the structures of the walls of *Heterotrypidæ,* as compared in tangential sections, is practically the same as in the cryptostomatous genus *Escharopora.* At present we see nothing indicating close relationship in this resemblance, but the fact that it is so should not be overlooked by those who have yet to be convinced of the bryozoan nature of the Trepostomata.

For purposes of convenience in classification, the *Heterotrypidæ* may be divided into two sections or subfamilies, the first, including *Heterotrypa, Dekayella,* and *Cyphotrypa* new genus, having numerous diaphragms, and the second, including *Dekayia, Petigopora, Leptotrypa, Stigmatella* new genus, and *Atactopora,* with diaphragms few or wanting.

Synopsis of generic characters

A. Diaphragms numerous:

1. *Heterotrypa* Nicholson:—Zoarium erect, frondescent; acanthopores of one kind; small; mesopores varying in number, generally abundant, sometimes wanting almost entirely.
2. *Dekayella* Ulrich:—Zoarium erect, ramose or frondescent; two sets of acanthopores, large and small; mesopores variable, generally more or less numerous.
3. *Cyphotrypa* new genus:—Zoarium massive or laminar, never erect; acanthopores of one kind; mesopores wanting.

B. Diaphragms few or wanting:

1. *Dekayia* Edwards and Haime:—Zoarium erect, irregularly ramose; acanthopores of one kind, generally of large size; mesopores very few, generally wanting.
2. *Petigopora* Ulrich:—Zoarium forming small, circumscribed patches; acanthopores well developed, of one kind; mesopores wanting.
3. *Leptotrypa* Ulrich:—Zoarium forming thin, evenly spread, parasitic expansions; acanthopores very small, never abundant; no mesopores.
4. *Atactopora* Ulrich:—Zoarium as in *Leptotrypa;* true mesopores wanting; surface studded with subsolid elevated spots; acanthopores small, very numerous, inflecting the walls.
5. *Stigmatella* new genus:—Zoarium incrusting, massive or subramose; mesopores present, often restricted to small spots; acanthopores small, more or less abundantly developed at

intervals between which they are wanting; in ramose forms they are developed in the extreme outer region.

Genus HETEROTRYPA Nicholson

Cumings, in a recent revision of the genera *Dekayia, Dekayella,* and *Heterotrypa,*[1] arrived at the conclusion that they represent one and the same generic type. He also believes that Ulrich's identification of *Monticulipora frondosa,* the genotype of *Heterotrypa,* is incorrect. According to his conception, *Monticulipora frondosa* is founded on a species of *Homotrypa* that occurs as a comparatively rare fossil in the upper beds of the Lorraine formation.

To determine the species *Heterotrypa frondosa,* the genotype of *Heterotrypa,* we sought and succeeded in securing specimens from D'Orbigny's type lot and also a fragment of Edward and Haime's figured specimen of *Chætetes frondosus.* For the first of these we are greatly indebted to Dr. M. Boule of Paris, and for the second to Dr. H. Douvillé of the École des Mines, Paris. To assure us as much as possible of the authenticity of the latter, Dr. Douvillé marked out on a sketch of Edwards and Haime's figure of this species the exact place from which the fragment sent us was nipped. Consequently, we now consider ourselves well equipped to settle beyond dispute the question of what D'Orbigny really meant by *Monticulipora frondosa.*

As can be readily seen from the views of thin sections of this fragment given on plate XI, the species, instead of being a *Homotrypa,* as claimed by Cumings, is the same as that so recognized by Ulrich more than twenty years ago.

The two specimens of *Monticulipora frondosa* selected by Dr. Boule from D'Orbigny's type lot are also of the same species as that represented by Edwards and Haime's figured specimen. The synonomy of *Heterotrypa frondosa* given by Ulrich in his work on the species, and later by Nickles and Bassler, therefore stands with Cumings' new name, *Dekayia perfrondosa,* as an additional synonym.

As to the value of the three genera discussed by Mr. Cumings, we do not deem this the proper place to go into the subject in detail. However, we still consider the three genera distinct and very convenient in classification if not wholly natural groups. It is true that Ulrich some years ago expressed the idea of combining the three genera, but this was at a time when *Dekayella* was the only genus of the three of which species were known in the Mohawkian and

[1] *Amer. Geologist,* XXIX, 1902, pp. 197–217.

Utica, and when it seemed quite probable that the Lorraine species of *Dekayia* and *Heterotrypa* were derived from the earlier genus. Now typical species of both *Dekayella* and *Heterotrypa* are known to range side by side through the Mohawkian and Cincinnatian groups. In a future work we hope to describe all these species and to discuss the relations of the genera of the family more fully than the purpose of the present paper justifies.

The following new species of *Heterotrypa* is only one of many awaiting an opportunity for adequate publication. The only reason for including it in this paper is to make the species available for stratigraphic purposes, it being one of the commonest and most characteristic fossils of the Catheys formation of the Trenton in middle Tennessee.

HETEROTRYPA PARVULIPORA new species

(PLATE XI, 4-6)

This fine species is very abundant in the Catheys limestone at a number of localities in Tennessee and is related to the type of the genus *H. frondosa* which is probably a descendant.

The type specimen of *H. parvulipora* is a large flabellate expansion 200 mm. in height and measuring the same at its broadest part. Frond varying from 10 to 15 mm. in thickness. Surface smooth, maculæ not a prominent feature, often scarcely distinguishable. Zoœcia small, angular, thin-walled, 10 in 2 mm. Mesopores few. Acanthopores small, generally few, but sometimes each angle of junction is occupied by one.

In the immature region the zoœcial tubes have thin wavy walls and are crossed by diaphragms at distances varying from one to three tube-diameters. The walls become thickened in the mature regions and here also diaphragms become as frequent as two to a tube-diameter. Tangential sections show especially well the structure of the walls and the distinct, clear-cut acanthopores.

Compared with *H. frondosa* (D'Orbigny), *H. parvulipora* has smaller zoœcia, fewer mesopores, smaller and generally fewer acanthopores. As already stated, specimens are abundant, but care must be exercised in distinguishing them from an associated new species of *Homotrypa* which resembles them very greatly in external features. Internally the *Homotrypa* is of course quite distinct.

Occurrence.—The type specimen comes from the Catheys limestone of the Trenton, along Love branch of Catheys creek in Maury county, Tennessee. Most localities showing this horizon in the Central Basin of Tennessee yield an abundance of specimens.

Cat. No. 43,186, U. S. N. M.

Genus DEKAYELLA Ulrich

As our synopsis of generic characters shows, the definition of this genus is the same as hitherto given by its author, with the exception that both ramose and frondescent species, instead of ramose only, are included. This leaves, as the main distinction between *Dekayella* and *Heterotrypa,* the presence of two sets of acanthopores, one large, the other small in the former, and only one, though often variable, set in the latter. Cumings has shown that acanthopores of all sizes, grading from that of the small set to the large kind, are present in the same section of various species of *Dekayia, Heterotrypa,* and *Dekayella.* We admit that this is so if the same section passes through all the stages of growth from the very mature part of the zoarium to the less mature regions. Such a section could hardly fail to show otherwise, for the acanthopores slowly increase in size and strength just as other parts of the zoarium do. We maintain, however, that sections taken through the same part of a mature region will show approximately the same structure throughout, and it is in such sections that the generic features of *Dekayella* are shown. The surface of well-preserved examples of this genus usually shows both sets distinctly. When this is not so, investigation reveals that the surface in this case does not represent, as it usually does, the most mature stage, the zoarium being overgrown by a young secondary layer of zoœcia.

We do not wish to maintain that the distinction between these two sets of acanthopores is so great that with thin sections one can always without the slightest difficulty distinguish them. Indeed very few species show them as distinctly as we have portrayed them on plate VII, 11, yet this is from an actual slide and is not imaginary or overdrawn. In some species they are so obscured, or the particular region in which they are typically developed is so difficult to strike, that it is not an easy matter to determine the generic position. As an example of this we may mention *Heterotrypa singularis* Ulrich, from the Richmond formation of Illinois, which until recently has been left as a *Heterotrypa.* We now have sections which demonstrate beautifully that it has the two sets of acanthopores of *Dekayella* and it must therefore be referred to that genus.

To sum up all we care now to state of *Dekayella* is that it embraces a number of related species having as a character in common the two sets of acanthopores but agreeing in other respects with *Heterotrypa.*

We believe that when a dozen or more species have, as in the case of *Dekayella,* a character in common which separates them from otherwise closely related forms, the best interests of classification demand that they be distinguished by a distinct name, whether of generic or subgeneric rank is of little consequence. Furthermore, it is contrary to accumulated knowledge of Nature's laws to expect that any character should remain hard and fast and not grade, at least in some species, toward other genera. However *Dekayella* may stand with respect to *Heterotrypa* in the final revision of these Bryozoa, we think that *Dekayia* will stand as a genus, not in the sense of Ulrich's definition of the genus in 1880,[1] but as defined in our synopsis of the *Heterotrypidæ* on a preceding page.

DEKAYELLA FOLIACEA new species

(PLATE VII, 10–12)

The discovery of this flabellate species with its well-developed large and small sets of acanthopores caused us to emend the generic diagnosis so as to include frondescent species. *Dekayella foliacea* grows into erect fronds of varying width and from 5 to 10 mm. in thickness. Externally the zoœcia are angular, an average of 8 in 2 mm., the mesopores few, and both sets of acanthopores usually well developed.

Diaphragms are remote in the axial region, indeed are generally wanting, but the peripheral zone is closely tabulated, 2 to 3 diaphragms being found in a distance equaling the diameter of a zoœcium. Mesopores are few, although the number is somewhat variable. The larger set of acanthopores is usually well developed, but sometimes, especially in very old conditions, the smaller set is obsolete.

The flabellate growth, rather few mesopores, and the double set of acanthopores form a combination that is readily distinguished from other *Heterotrypidæ*. The flabellate form of the zoarium alone suffices in separating it from congeneric species.

Occurrence.—Lexington limestone of the Trenton, Lexington, Kentucky.

Cat. No. 43,187, U. S. N. M.

Genus LEPTOTRYPA Ulrich

The genus *Leptotrypa* as defined by Ulrich in 1890[2] and 1893[3] proved to be quite a heterogeneous assemblage of species and an unwarranted extension of the original diagnosis. In the first place,

[1] *Amer. Pal. Bryozoa.*

[2] *Geol. Surv. Illinois*, VIII, p. 377.

[3] *Geol. Minnesota*, III, p. 316.

our last published conception of the genus is affected by the division of the Trepostomata into the two sections discussed on a preceding page. In the first of these two primary divisions, the Amalgamata, the walls of adjoining zoœcia are fused together, or, using a term more commonly employed, amalgamated. In the second division, the Integrata, the walls remain separate, and divide readily along the sharp, dark line which marks the contact between adjoining tubes. Now, the type of *Leptotrypa* clearly belongs to the *Heterotrypidæ,* which are good Amalgamata, while other species referred to the genus have the wall structure characterizing the Integrata, so that a splitting up of the genus is necessitated on that ground alone. Besides, we have come to pay more attention to the tabulation of the tubes and with gratifying results in the way of natural classification.

In accordance with the facts brought out by our recent studies, we had to restrict *Leptotrypa* very nearly to the limits originally assigned to the genus in 1883. As revised, the genus includes only three or four parasitic species, *L. minima* Ulrich, *L. ornata* Ulrich, *L. clavacoidea* (James), and several undescribed species which form thin expansions made up of tubes in which diaphragms are very few or wanting. This restriction leaves a number of species which find a place naturally enough under *Amplexopora* (e. g., *L. filiosa* (D'Orbigny), *L. petasiformis* (Nicholson), etc.), but for a larger number new generic groups are here established. *Cyphotrypa* is necessary for the reception of the massive *Heterotrypidæ* with well-developed diaphragms, while species of the type of *L. clavis* and *L. irregularis* Ulrich are referred to the new genus *Stigmatella.* These removals will be further discussed under their respective genera.

Genus Cyphotrypa new genus

Massive *Heterotrypidæ.* Zoœcial walls thin, amalgamated, the central portion light-colored; tubes prismatic, with numerous well-developed diaphragms; mesopores wanting, acanthopores well developed.

Genotype:—Leptotrypa acervulosa Ulrich, a characteristic Trenton fossil in Iowa, Minnesota, and Kentucky.

As stated in our remarks on *Leptotrypa,* the restriction of that genus to species agreeing strictly with its type necessitated the erection of a new genus for the massive and well-tabulated Amalgamata that previously had been referred to *Leptotrypa.* The importance of the characters that distinguish these massive forms from the typical species of *Leptotrypa,* and consequently the desirability of the separation, became more and more evident as they grew in number. Up to this date we have determined, without exhausting our material, no fewer than fifteen species having the characters above ascribed to *Cyphotrypa*. Of this number only four, *Leptotrypa acervulosa, L. informis, L. semipilaris,* and *L. stidhami,* all of Ulrich, have been described. Only two of the new species are described in this paper. The others must await another opportunity.

Commencing with the Stones River group, the genus is represented in nearly all of the divisions of the Ordovician. A single new species occurs in the Niagaran, while another new form in the Helderbergian of Maryland appears to be the last representative of the genus.

CYPHOTRYPA FRANKFORTENSIS new species

(PLATE VIII, 7-9)

The zoarium in this well-marked species forms large, often undulating expansions usually 7 cm. or more in diameter and 1 cm. in height; but sometimes heaped-up masses, 4 or 5 cm. high, occur as the result of the superposition of several layers of zoœcia. The surface usually bears small, sharp monticules. Zoœcia small, 9 to 10 in 2 mm., five or six sided, with very thin walls. Acanthopores rather large and distinct but not abundant, averaging only about one to each zoœcium. Diaphragm entirely wanting in the immature region and from one to two tube-diameters apart in the mature zone which is distinguished only by the fact that diaphragms are here developed.

The large monticulated masses formed by this species, its small zoœcia and few acanthopores, and the absence of diaphragms in the immature regions, distinguish it. Small weathered specimens or fragments may be confused with *C. acervulosa,* which has zoœcia of the same size, but as the zoœcial tubes are abundantly tabulated in that species, collectors should experience little difficulty in distinguishing even small fragments.

Occurrence.—Common in the shaly limestones at the top of the Trenton on Reservoir hill, Frankfort, Kentucky. Less abundant in the vicinity of Burgin, Kentucky, where it seems to occur in a lower bed of the same formation.

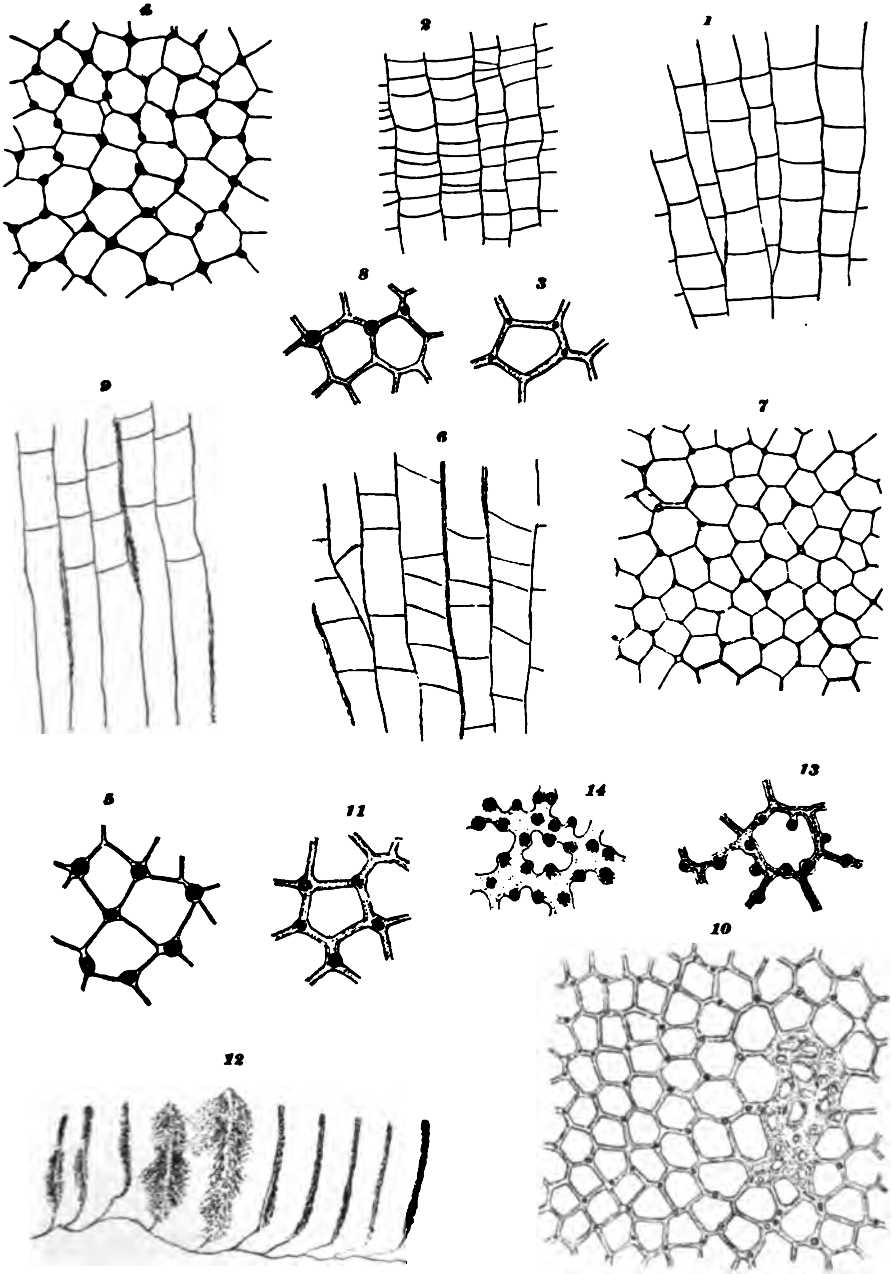
Cat. No. 43,188, U. S. N. M.

CYPHOTRYPA ACERVULOSA (Ulrich)

(PLATE VIII, 1-3)

1893. *Leptotrypa acervulosa* ULRICH, Geol. Minnesota, III, p. 318, pl. XXVII, 24, 25.

This widely-distributed species, which we have made the genotype, forms small, irregular or subglobular, smooth masses, 15 to 20 mm.



GENERA AND SPECIES OF TREPOSTOMATA

in diameter. Zoœcia thin-walled, 9 to 10 in 2 mm. Acanthopores few, small but well marked. In immature regions diaphragms from one to one and a half times their own diameter apart; in the mature regions two or three times as numerous.

The small, usually subglobose, zoarium, few acanthopores and the tabulation characterize this species. An externally very similar species of *Cyphotrypa* occurs in the Richmond formation of Ohio.

Occurrence.—Trenton of Iowa, Minnesota, Kentucky, and Canada.

Cat. Nos. 43,189–43,191, U. S. N. M.

CYPHOTRYPA WILMINGTONENSIS new species

(PLATE VIII, 4–6)

Zoarium of small, smooth, rounded or subglobular masses about 10 mm. in diameter. Zoœcia thin-walled, angular, and when well preserved exhibiting strong acanthopores at the junction angles. Zoœcia of the maculæ but slightly larger than the ordinary, 7 to 8 of the latter in 2 mm. Thin sections show that the acanthopores are large and distinct, with a well-marked central perforation, and usually occupy only the angles formed by adjoining zoœcia. Diaphragms twice their own diameter or more apart in the immature region and two to three times as numerous in the mature.

The size of the zoœcia, numerous large acanthopores, and small globular method of growth distinguish this species from most others of the genus. It has much larger acanthopores than *C. acervulosa*.

Occurrence.—In shaly limestone of Richmond age at Wilmington, Illinois.

Cat. No. 43,192, U. S. N. M.

Genus ATACTOPORA Ulrich

Until recently this genus has been classed with the *Amplexoporidæ*, but since we have come to appreciate the importance of differences in the minute structure of the zoœcial walls, we can see that it is more naturally placed with the *Heterotrypidæ*. The wall structure is precisely as in *Heterotrypa*, the light-colored line or band being present between adjoining zoœcia. The incrusting zoaria, with the subsolid elevated maculæ and the numerous small acanthopores inflecting the zoœcia, characterize the genus. Two species have been described, *A. hirsuta* the genotype and *A. maculata*. Several new forms are known, the following, though a good *Atactopora*, having fewer acanthopores than usual.

ATACTOPORA ANGULARIS new species

(PLATE VIII, 10-12)

Zoarium, as is nearly always the case in this genus, parasitic upon cephalopods. Surface generally smooth, the solid maculæ seldom elevated. Zoœcia angular, 8-9 in 2 mm. Acanthopores less numerous than in other species of the genus, these structures being usually limited to the junction angles, while the number to each zoœcium rarely exceeds three. Maculæ small but as usual composed of small or aborted zoœcia which are filled up with age by a secondary deposit of dense, laminated tissue.

Occurrence.—Lower Richmond, Waynesville, Ohio.

Cat. No. 43,193, U. S. N. M.

Genus PETIGOPORA Ulrich

To ascertain whether or not certain or all of the species referred to this genus are dwarfed mutations or possibly only young stages of normally ramose or massive forms of other genera of the *Heterotrypidæ,* has been a most difficult task. The problem, moreover, still confronts us and its solution seems as difficult as ever. We tried to show, for instance, that *P. gregaria* was merely the beginning of a secondary layer of zoœcia on branches of species of *Dekayia,* but when it was found growing on all sorts of Bryozoa, and that it always maintained a reasonably definite size, we realized that some other explanation of its existence was in order. So we let it stand, and with it the genus. The zoœcial structure of *P. asperula* Ulrich again is essentially the same as that of the associated *Dekayia appressa,* but among the hundreds of specimens of these species that we have collected there is none to connect them. Finally, *P. petechialis,* or species resembling it, occurs almost throughout the Mohawkian and Cincinnatian groups, generally in association with other *Heterotrypidæ.* We have, however, found zoaria of *Petigopora* in horizons from which no other similar Heterotrypoids are known. At present we can regard such a fact only as indicating that these small incrustations are species by themselves. The following neat species occupies a well-marked horizon and is of widespread occurrence geographically in the Ohio region.

PETIGOPORA OFFULA new species

(Not figured)

The new species for which we propose this name differs from the previously described species in forming small, usually subglobular masses, 2 to 4 mm. in diameter, by growth around associated smaller organisms. Occasionally the zoaria are discoid or irregular. The acanthopores are strongly developed and many specimens bristle with them. Zoœcial apertures rounded or subangular, 9–10 in 2 mm.

Occurrence.—Very abundant in the uppermost stratum of the Warren beds of the Cincinnatian. The types are from Middletown, Ohio; but Clarksville, Oregonia, Lebanon, and other localities in southwestern Ohio furnish exposures where the species can be found in abundance.

Cat. Nos. 43,194–43,196, U. S. N. M.

Genus STIGMATELLA new genus

Zoarium variable, ranging from incrusting to irregularly massive and ramose. Zoœcia angular, rounded, or irregularly petaloid, the shape depending upon the presence (or absence) of mesopores and the number of acanthopores. Typically the zoarial surface exhibits at regular intervals maculæ or spots composed of mesopores, although in some species the usual monticules or clusters of large cells occur. Acanthopores always present but variable in number, intermittent, developed chiefly in narrow zones, sometimes inconspicuous but more often so numerous as to give the surface a decidedly hirsute appearance. Mesopores, when present, developed in mature region only, their number being variable even for the same species.

The zoœcial tubes have thin walls in the axial region and these become but slightly thickened in the peripheral region where a few unusually delicate diaphragms are inserted. In vertical sections the walls exhibit at rather regular intervals in the peripheral region thickenings somewhat similar to those occurring in *Stenopora.* These thickenings occur approximately at the same height in the walls, and tangential sections through these zones give the full development of acanthopores. Minute structure of walls as shown in tangential sections, of the type that characterizes the *Heterotrypidæ.*

Genotype.—*Stigmatella crenulata* new species. Richmond formation, Ohio.

This genus is proposed to receive a few species which from time to time have been referred to *Monticulipora, Leptotrypa,* and *Monotrypa* by authors, for the new forms here described and finally for several additional undescribed species whose publication had to be deferred on account of a lack of space. Although differing widely in zoœcial habit, these species seem to form a natural group of the *Heterotrypidæ,* distinguished by the periodic thickening of the walls of the zoœcial tubes and the accelerated development of the acanthopores in these thickened zones. The incrusting forms without mesopores may be confused with *Leptotrypa,* but the characteristics just mentioned distinguish them from species of that genus. For the same reason and also because of the absence of a second set of acanthopores, the ramose forms with mesopores are distinguished from species of *Dekayella.* The periodic development of the acanthopores and thickening of the walls separate the new genus from *Dekayia* with which it agrees in the sparse development of diaphragms. So far as known the genus is confined to the Cincinnatian rocks. Of described forms it includes *Leptotrypa clavis* Ulrich from the Utica, and *Monticulipora* (*Monotrypa*) *dychei* James (see plate x, fig. 11), and *Leptotrypa irregularis* Ulrich (see plate x, figs. 5, 6; plate XIV, figs. 6–8) from the Lorraine.

STIGMATELLA CRENULATA new species

(PLATE IX, 1–4; PLATE XIV, 1, 2)

Zoarium composed of cylindrical, subcylindrical or compressed, frequently dividing stems 10 mm. or more in diameter, arising from a broad base and forming a clump probably seldom more than 50 mm. high. Surface even, but in well preserved mature specimens spinulose because of the many acanthopores. Maculæ well marked, generally composed of mesopores which make up the characteristic "spots" but sometimes formed exclusively of zoœcia larger than the ordinary. Zoœcial apertures small, about 9 in 2 mm. with their walls thin and often beautifully inflected by the numerous small acanthopores. Mesopores present, variable in number but usually few and mostly aggregated in the maculæ. In the axial region the zoœcial tubes have thin, finely crenulated walls, and occasionally a diaphragm or two. In the mature region the walls increase slightly in thickness, mesopores and acanthopores develop, and thin diaphragms cross the zoœcial tubes and mesopores at varying though always comparatively remote intervals.

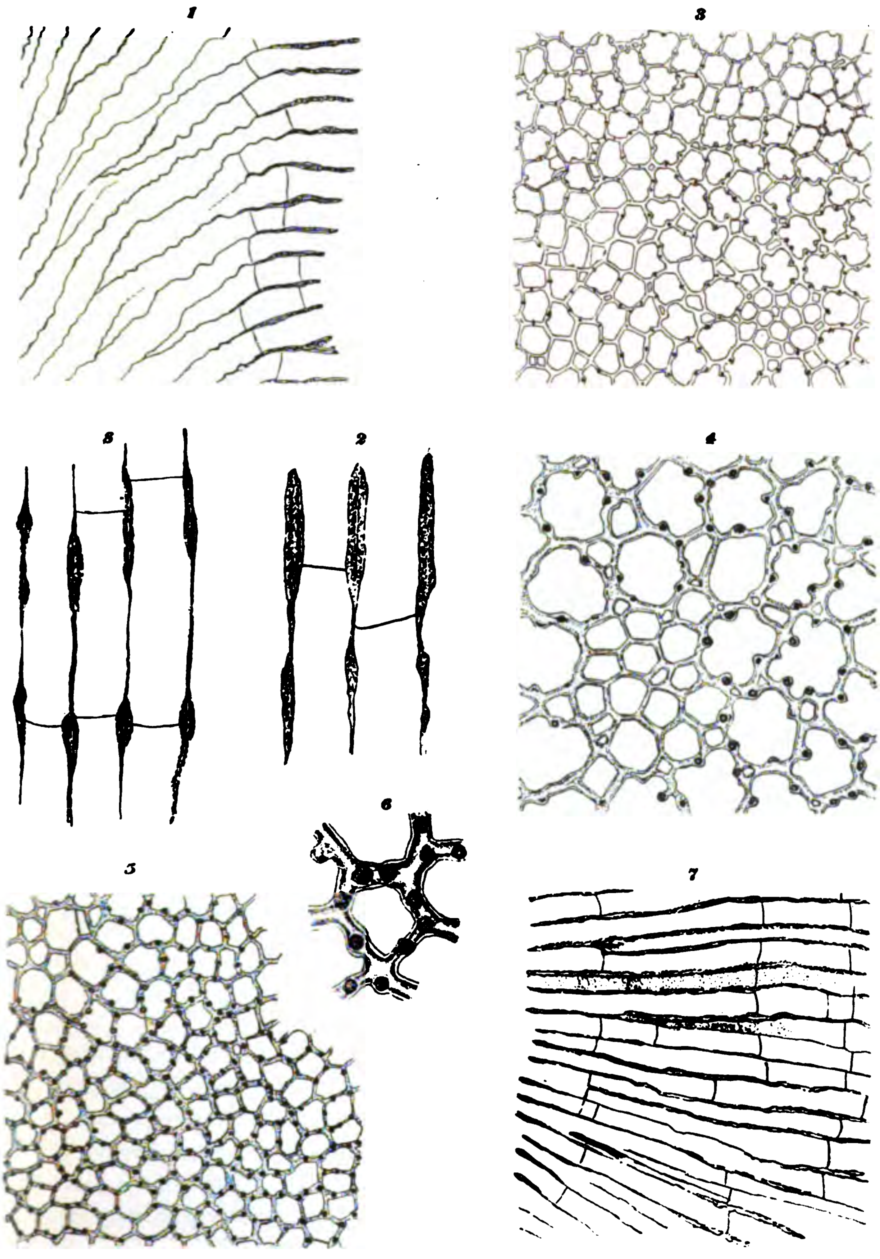
Occurrence.—Very abundant in lower part of the Richmond formation at Hanover, Butler county, Ohio. Less common at the same horizon near Oxford, Waynesville, Clarksville, and other localities in Ohio.

Cat. Nos. 43,197–43,199, U. S. N. M.

STIGMATELLA SPINOSA new species

(PLATE IX, 5–8)

The method of growth in this species is similar to that obtaining in *S. crenulata,* but under a lens *S. spinosa* is distinguished at once by



GENERA AND SPECIES OF TREPOSTOMATA

having no mesopores and so many small acanthopores indenting the zoœcial walls that the surface appears granulose rather than spinose, which term applies better in other species of the genus. Continuing the comparison with *S. crenulata,* the zoœcia are found to be a little smaller, about 10 occurring in 2.0 mm., and the axial portion of the tube walls straighter.

Thin sections of this species are both beautiful and instructive. In vertical sections the periodic development of the acanthopores, which is a feature of the genus, is shown especially well. Diaphragms few and of irregular distribution.

Occurrence.—Richmond formation, Versailles, Indiana.

Cat. No. 43,200, U. S. N. M.

STIGMATELLA PERSONATA new species

(PLATE XII, 1-3)

This is one of the non-mesopored species of the genus and forms smooth, branching zoaria very much like *S. crenulata* and *S. spinosa.* From the former it is distinguished by having fewer acanthopores, no mesopores, and in lacking the crenulation of the walls in the immature region. From *S. spinosa* it is separated by its larger zoœcia, 7 to 8 being found in 2 mm. while 10 are required in that species to cover an equal distance. The acanthopores in *S. personata* also afford a difference, being but seldom more numerous than the junction angles which they usually occupy. In *S. spinosa,* it will be remembered, they are so abundant that they almost completely surround the zoœcium.

Occurrence.—Uncommon in the Richmond formation at Hanover, Ohio.

Cat. No. 43,201, U. S. N. M.

STIGMATELLA INTERPOROSA new species

(PLATE XII, 4, 5)

Associated with *S. crenulata* but distinguished by smaller, more irregular growth, the branches frequently intertwining and being of all shapes from small cylindrical, 3 or 4 mm. in diameter to irregular fronds 10 mm. or more broad. About 9 zoœcia in 2 mm.

Mesopores with diaphragms their own diameter apart; zoœcial tubes with few diaphragms. Zoœcia usually separated by numerous mesopores. Acanthopores small and relatively few in number.

The small zoarium, smooth surface, small and few acanthopores and numerous mesopores are the specific characters.

Occurrence.—Abundant in the Richmond formation at Hanover, Ohio.

Cat. No. 43,202, U. S. N. M.

STIGMATELLA NANA new species

(PLATE X, 7–10; PLATE XIV, 11, 12)

This species has mesopores and is related in other respects to the Richmond form, *S. interporosa.* It may be distinguished, however, by its more numerous acanthopores and less numerous mesopores, and by other, less important, differences. The zoarium of *S. nana* is small and irregularly branched. The surface is often hirsute because of the acanthopores which, although quite numerous, are small. In *S. interporosa* the zoarium, although also of small size, consists of frequently dividing and more regularly formed branches, on which the acanthopores are seldom observable. The tabulation of the zoœcia and mesopores is much alike in the two species, the only difference noted being that diaphragms occur more frequently in the zoœcial tubes of *S. interporosa.*

Occurrence.—Very abundant in the Utica formation at West Covington, Kentucky, and other localities in the vicinity of Cincinnati. Ohio. The exact horizon is about 25 feet above the top of the Trenton.

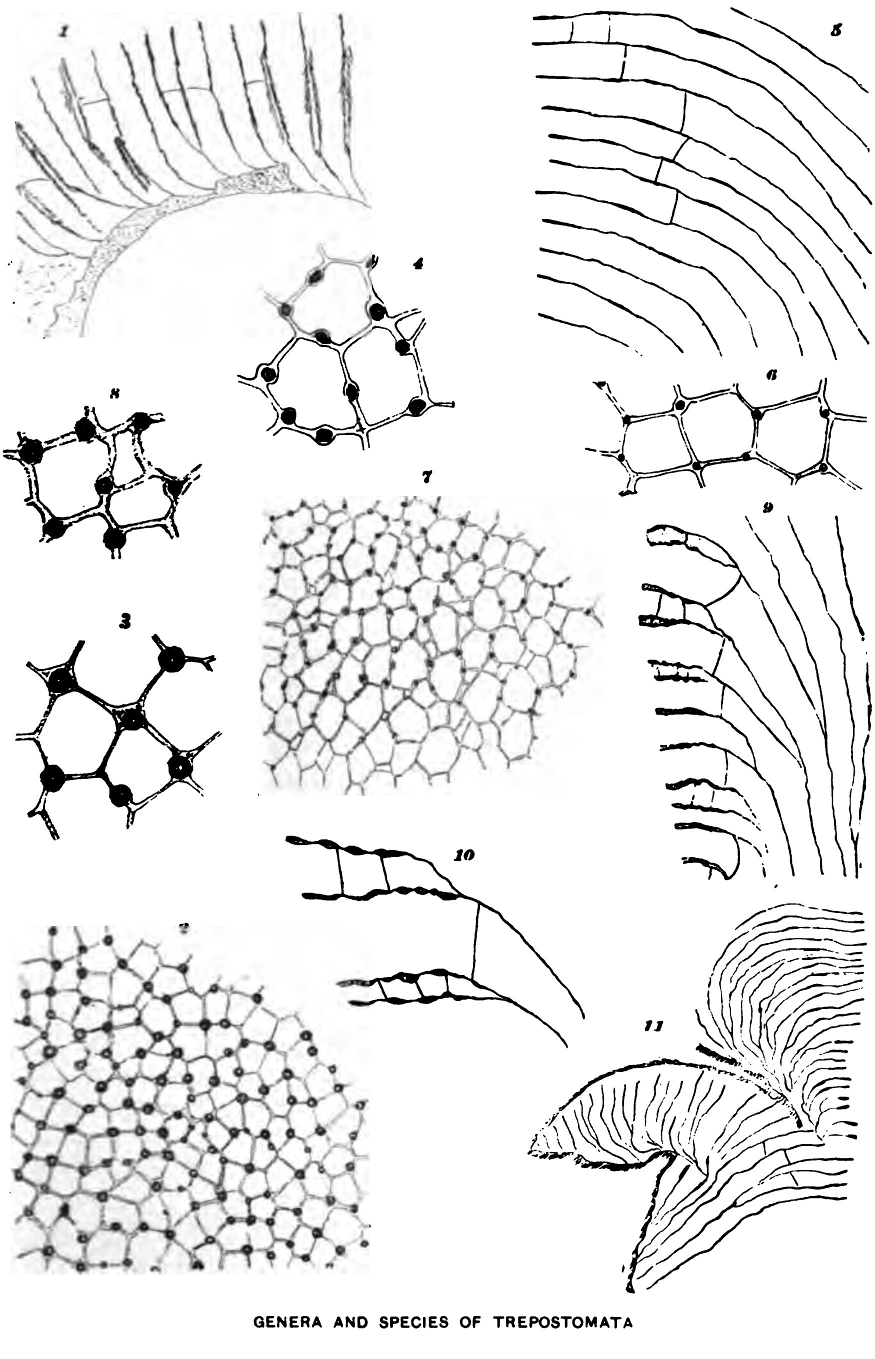
Cat. No. 43,203, U. S. N. M.

STIGMATELLA NICKLESI new species

(PLATE X, 1–3; PLATE XIV, 9, 10)

This species is related to *S. clavis* (Ulrich) and resembles that form in its zoarial characteristic, but the unusually large acanthopores will distinguish it at once. In *S. nicklesi* the acanthopores are generally situated only in the junction angles of the zoœcia and are less numerous than in *S. clavis.* The numerous acanthopores of the latter species (see plate X, 4) inflect the walls, giving the petaloid appearance characteristic of several species of the genus. In *S. nicklesi* this inflection has not been observed, the walls being thin and straight, and the large acanthopores confined to the angles. The two species are further distinguished by their methods of growth, *S. clavis* forming neat, tightly adhering, club-shaped zoaria about crinoid columns, while *S. nicklesi* loosely covers similar objects.

The specific name is in honor of Mr. John M. Nickles, of the U. S. Geological Survey, who discovered the species in considerable numbers and recognized its distinctness.



GENERA AND SPECIES OF TREPOSTOMATA

Occurrence.—Upper part of the Fairmount beds of the Lorraine at Cincinnati, Ohio. Common but vertical range limited to less than a foot.

Cat. No. 43,204, U. S. N. M.

Family CONSTELLARIIDÆ Ulrich

Genus CONSTELLARIA Dana

CONSTELLARIA TERES new species

(Not figured)

This new species is readily distinguished from all described forms of the genus by its uniform method of growth. The zoarium consists of rigid subcylindrical to cylindrical solid stems, 5 to 10 mm. in diameter, dividing by bifurcation at intervals of rarely less than 50 mm. The maculæ are usually but slightly elevated and are a trifle smaller than in such forms as *C. florida*, and on account of the regular method of growth often show an arrangement in ascending diagonally intersecting lines. However, when the surface is nearly smooth the maculæ often consist of star-shaped centers from the rays of which long rows of mesopores radiate.

The size and shape of the zoœcia are essentially as in *C. florida*, but vertical sections show differences in the tabulation of the zoœcia. Diaphragms are almost entirely absent in the axial region of *C. florida*, but in *C. teres* they occur at intervals varying from two to three times the tube-diameter. This difference in tabulation applies also to the peripheral region, the diaphragm in *C. teres* being here again more abundant.

Figures of a group of specimens belonging to this and the following species are given on the plate of characteristic fossils of the Columbia folio recently issued by the U. S. Geological Survey.

Occurrence.—The types are from the shales at the top of the Bigby limestone of the Trenton at Columbia, Tennessee, where the species is very abundant. It also occurs, but in less abundance, in the Catheys limestone. Numerous localities in Tennessee and Kentucky, exposing especially the lower of these two horizons, furnish specimens.

Cat. Nos. 43,205–43,207, U. S. N. M.

CONSTELLARIA FLORIDA var. EMACIATA new variety

(Not figured)

This subordinate name is proposed for a very abundant fossil of the Bigby limestone of Tennessee. The form agrees in all essential internal features with the Lorraine *Constellaria florida,* and differs only in growth and in the arrangement and size of the "stars." The usual growth obtaining in *C. florida* is of rather broad, flat branches, seldom less than 10 mm. in breadth and 3 or 4 mm. in thickness, dividing rather regularly at intervals of several centimeters. *C. florida emaciata,* however, is dwarfed in growth, the branches being usually rounded and from 3 to 5 mm. in diameter, but sometimes reaching a breadth of 6 or 7 mm. Division occurred at short, irregular intervals, and an entire zoarium consisted of a small clump of closely interwoven narrow branches, instead of a rather broad expansion as in *C. florida.* Another difference is in the shape of the stellate maculæ which, although of about the same size in both species and variety, are more sharply and narrowly rayed in the variety than in the species.

Occurrence.—The types are from the Constellaria bed at the top of the Bigby limestone at Columbia, Tennessee, where specimens can be found literally by the million. The species occurs abundantly also in the shaly parts of the Catheys limestone. Mt. Pleasant, Nashville, and many other localities in the Central Basin might be mentioned where the variety may be had in abundance.

Cat. No. 43,208, U. S. N. M.

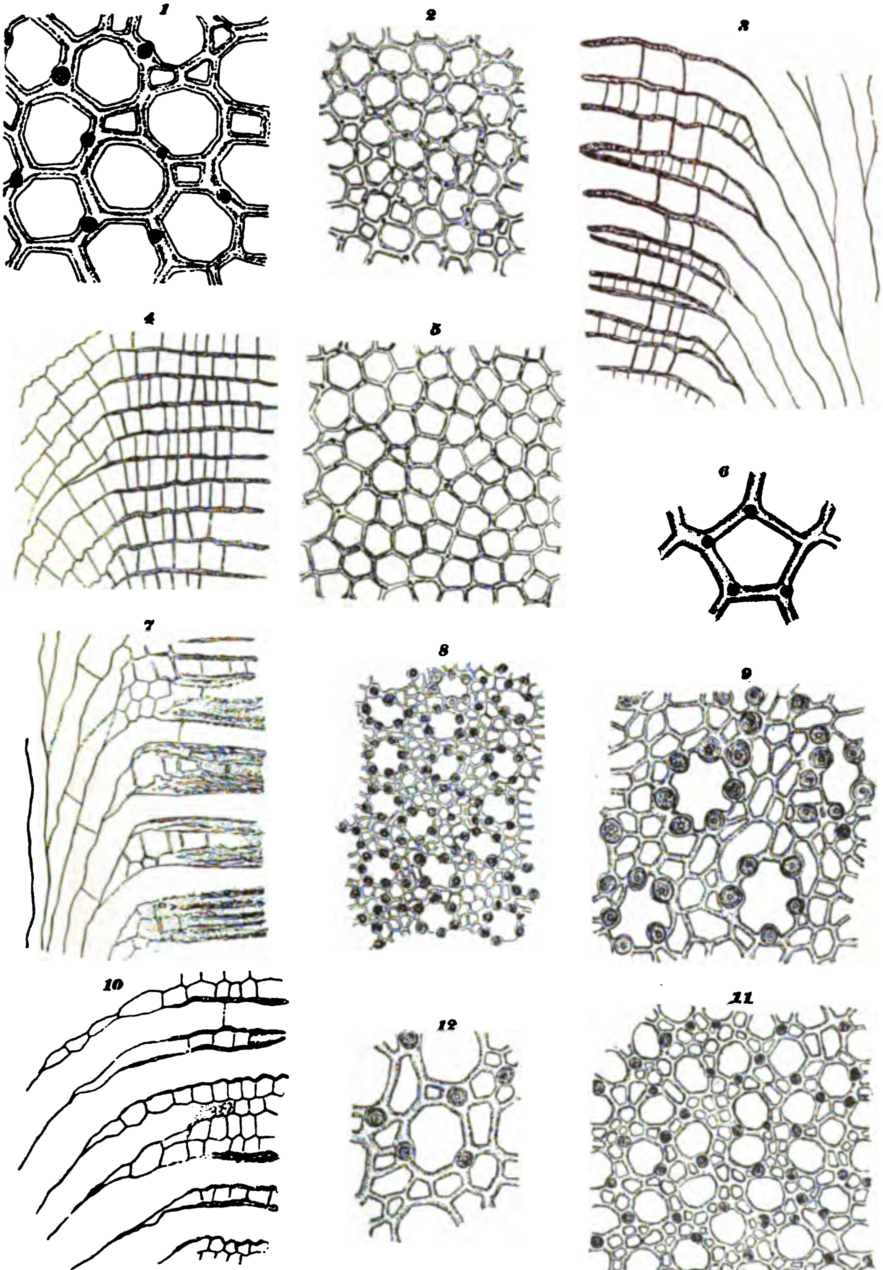
Family BATOSTOMELLIDÆ Ulrich

This family stands for the present essentially as defined by Ulrich in 1890[1] and again in 1896.[2] When worked up with the care bestowed upon some of the other families, notably the *Heterotrypidæ,* doubtless some changes will become necessary. Our present effort consists of a few remarks and figures tending to fix the characters of two genera of the family, namely, *Lioclema* and *Lioclemella,* while a revision of the Stenoporoids will form the subject of a future paper.

Genus LIOCLEMA Ulrich

Recent study of a considerable amount of material from several Silurian horizons shows that this generic type, which began with a single species in the Richmond, was more prolific in species in Silurian times than we suspected. Adding these undescribed species to those previously known, and considering that this group ranges in time from the Richmond to the close of the Mississippian, the genus has grown to be the most important of the trepostomatous genera having representatives in the Paleozoic rocks. Under these cir-

[1] *Geol. Surv. Illinois,* VIII, p. 375.
[2] Zittel, *Text-book Pal.* (Engl. ed.), p. 277.



GENERA AND SPECIES OF TREPOSTOMATA

cumstances, it is thought desirable to fix the essential internal characters of the genus as exemplified in the genotype, *L. punctatum* (Hall), the small illustrations of this species published by the senior author in 1882 being scarcely sufficient for the purpose. We have accordingly prepared the drawings reproduced on plate XI, 7–9.

Lioclema punctatum is a very abundant fossil in the Keokuk formation of the Mississippi valley, and strictly ramose in its habit of growth. It may be readily distinguished from associated ramose bryozoa by its slender branches and the appearance they have to the naked eye of being smooth and as composed of zoœcia with small and widely separated apertures. When magnified, the interapertural spaces are seen to be occupied by rows of mesopores and numerous acanthopores.

The publication of most of the Silurian forms is already arranged for in papers by one or both of the writers. The following new Devonian species, having been worked up with the rest, had to be included in this paper, or have its publication postponed indefinitely.

LIOCLEMA MONROEI new species

(PLATE XI, 10–12)

Zoarium subramose, the branches being smooth and cylindrical or compressed, and 10 mm. or less in diameter. Zoœcial apertures polygonal, 6 in 2 mm., isolated from each other by small angular mesopores. Diaphragms extremely few in the zoœcial tubes, but abundant in the mesopores. Acanthopores large and conspicuous, but rather few, seldom more than three to a zoœcium.

The species is in some respects intermediate between the genotype *L. punctatum* and the Chemung species *L. occidens* (Hall and Whitfield). Compared with the former, the more robust branches, less numerous mesopores and acanthopores, and larger zoœcia of *L. monroei*, are features easily recognized. *L. occidens* has somewhat smaller zoœcia and few and smaller acanthopores, and more abundant diaphragms in the zoœcial tubes.

This species is named in honor of Mr. Charles E. Monroe of Milwaukee, Wis., who collected the specimens at Bethany, New York.

Occurrence.—Hamilton formation, Bethany, New York.

Cat. No. 43,209 U. S. N. M.

Genus LIOCLEMELLA Foerste

Lioclemella FOERSTE, Geol. Surv. Ohio, VII, 1895, p. 600.

This genus was briefly defined by Foerste in the work above cited and founded upon a common form of the Clinton shales of

Ohio, which he had previously described as a species of *Callopora*. As the internal characters of the genotype have not been figured, we make use of this opportunity to publish illustrations (plate XII, 6–9) of thin sections prepared from authentic examples. The relations of the genus are with *Lioclema*, and it would be difficult to point out satisfactory differences in their internal characters. However, the zoarial habit of growth of *Lioclemella*, consisting of club-shaped or sparsely divided branches, pointed at the proximal extremity for articulation with an attached, expanded base, is deemed of sufficient importance to justify the recognition of the group generically.

Besides the species listed in Nickles and Bassler's *Synopsis of American Fossil Bryozoa*, the genus will contain at least several other good species from the Richmond formation of Ohio and the Rochester shales of New York.

Division II.—*INTEGRATA* NEW DIVISION

Trepostomata in which the boundaries of adjacent zoœcia are sharply defined by a black divisional line.

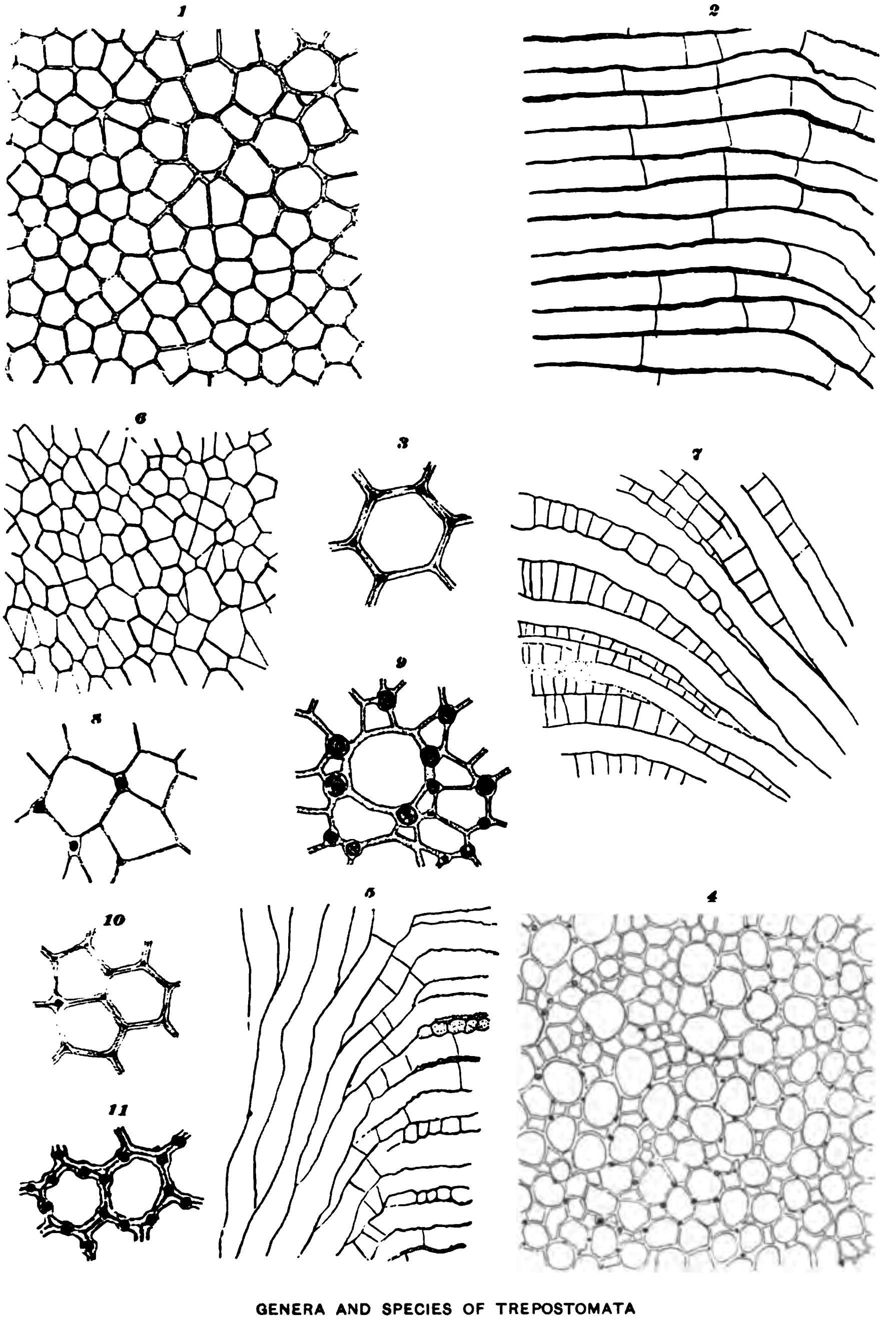
Family AMPLEXOPORIDÆ Ulrich

This family includes the most simple types of the Integrata. On account of this simplicity and the practical absence of mesopores, they also show the duplex character of the wall which separates adjoining zoœcia and upon which this division is founded, in a more satisfactory manner than the other families. The black divisional line is always in evidence, while in the *Calloporidæ* and *Trematoporidæ* it is generally obscured by the interposed mesopores and is certainly demonstrable only in those occasional species in which the development of mesopores has been reduced to a minimum.

The removal of *Leptotrypa* and *Atactopora* to the *Heterotrypidæ* has materially affected the status of the *Amplexoporidæ*. Possibly it would be wise to replace these genera, in part at least, by the recognition of a genus for such permanent integrate Leptotrypas as *L. discoidea* (Nicholson). The genotype of Eichwald's genus *Orbipora*, *O. distincta*, as worked out by Dybowski,[1] seems to belong to this group and future research may show *Orbipora* to be the proper genus for the reception of *L. discoidea*.

The new genus *Rhombotrypa* has been long in contemplation, and

[1] *Die Chætetiden der Ostbaltischen Silur.-Form.*, p. 57.



GENERA AND SPECIES OF TREPOSTOMATA

now that the type of structure expressed by it has turned up in the Silurian faunas, we no longer hesitate in defining it.

Genus Amplexopora Ulrich

This genus originally included ramose species only, but we now believe it advisable to extend its limits so as to include several *Amplexoporidæ* left over after the restriction of *Leptotrypa* to its typical species and the distribution of the bulk of its species between the new genera *Cyphotrypa* and *Stigmatella.* Among these unplaced species are *L. filiosa* (D'Orbigny) and *L. petasiformis* (Nicholson) which can be shown to be closely related to such typical species of *Amplexopora* as *A. septosa* Ulrich (see plate XII, 10, 11). James' *Monticulipora welshi,* a subramose form or variety of *L. petasiformis,* bridges over the gap between the two groups very nicely. *Leptotrypa discoidea* (Nicholson) is not so easily provided for, we being as yet undecided as to whether it belongs to the Integrata or the Amalgamata. If it is of the former type, then it is still a question whether it would not be advisable to recognize another genus for it.

The propriety of referring massive as well as ramose species to this genus is also confirmed by the close relations of two of the following new species, namely, *A. columbiana* and *A. ampla.*

As to the geological range of the genus, it now appears not to extend beyond the top of the Ordovician. The Devonian species like *Monticulipora moniliformis* Nicholson, that have been referred here, are Amalgamata and must be provided for elsewhere. At some future time we hope to discuss these in connection with the rest of the Devonian Trepostomata.

AMPLEXOPORA COLUMBIANA new species

(Plate XIII, 1-4)

Zoarium massive, generally subglobose, an inch or more in diameter; rarely the growth is irregular, resulting in shapeless masses several inches in their greatest dimension. Surface without monticules, but exhibiting maculæ composed of zooecia reaching nearly twice the diameter of the average cell. No mesopores. Zooecial apertures polygonal, 6 to 7 of those occupying the intermacular spaces in 2 mm.; walls thin, not often exhibiting the acanthopores, which, in the fully matured condition, recurring at intervals during the growth of a colony, are rather large, well defined, and about half as numerous as the angles of junction to which they are almost wholly confined.

In tangential sections the walls present the sharply-defined median line separating adjoining zoœcia characteristic of the family *Amplexoporidæ*. In deep sections the walls are extremely thin and the acanthopores very small. Vertical sections show repetitions of immature and mature regions, the former being distinguished by thin walls and diaphragms a tube diameter or more apart, the latter by appreciably thickened walls and more crowded diaphragms. In the mature regions many of the diaphragms are further distinguished by being recurved, usually from one wall only, but not infrequently from both sides, the structures in the latter case being infundibuliform.

The zoœcia in this fine species are larger than in any other now referred to this genus, and this feature, in connection with the presence of recurved and funnel-shaped diaphragms, distinguishes this form from all other massive or discoid species of the genus.

Occurrence.—This is one of the most characteristic species of the Lorraine formation in the Central Basin of Tennessee. The types are from the top of Mt. Parnassus at Columbia, Tennessee, although many other localities in Maury and other counties furnish an abundance of specimens.

Cat. Nos. 43,210–43,212, U. S. N. M.

AMPLEXOPORA AMPLA new species

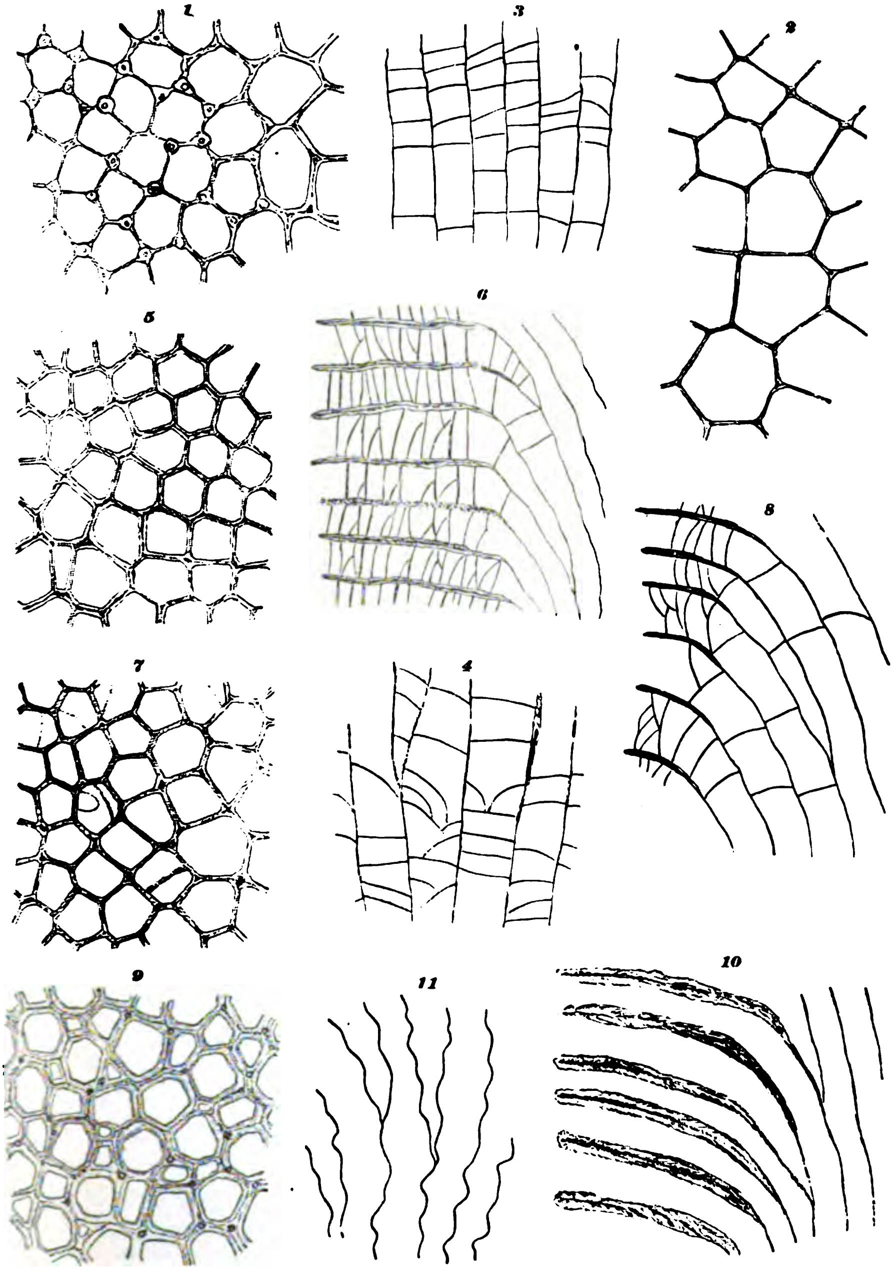
(PLATE XIII, 7, 8; PLATE XIV, 3)

In size of zoœcia this species agrees fairly well with the preceding, with which it is also generally associated, but the two are readily distinguished by their different methods of growth. In the hundreds of specimens observed *A. columbiana* is always massive, while *A. ampla* adheres as strictly to the ramose habit of growth. Its branches are smooth, divide frequently, and are usually about 10 mm. in diameter. The zoœcia are large, about 7 in 2 mm., with subangular apertures and rather thin walls. The acanthopores are small and so far have been observed only in thin sections. They seem never to reach the size of those in *A. columbiana.* Diaphragms occur at intervals of several tube-diameters in the axial region, but in the peripheral they are much more abundant, many of them here also being funnel-shaped.

A. ampla is closely related to *A. cingulata* Ulrich, the type species of the genus, but has larger zoœcia and fewer acanthopores.

Occurrence.—Abundant in the Lorraine formation at Nashville and Columbia, and many other localities in Tennessee, where these strata are exposed. Rather rare in the Fairmount beds of the Lorraine at Cincinnati, Ohio, and vicinity.

Cat. Nos. 43,213–43,215, U. S. N. M.



GENERA AND SPECIES OF TREPOSTOMATA

AMPLEXOPORA CYLINDRACEA new species

(PLATE XIII, 5, 6; PLATE XIV, 4, 5)

This species resembles the last two considerably in internal characters, but as it has a decidedly different method of growth, besides several minor peculiarities and, moreover, marks a lower geological horizon, we have decided to recognize it as a distinct species.

Compared with *A. ampla,* the zoarium of *A. cylindracea,* consisting of straight, infrequently-branching, narrow, cylindrical stems, 5 or 6 mm. in diameter, is readily distinguished from the short, thick, frequently-branching stems of that species. The rounded masses of *A. columbiana* are too different externally to be confused with either of the two species.

Occurrence.—Abundant in the lower part of the Catheys limestone of the Trenton at Nashville, Tennessee. Here it occurred in a shaly bed containing many other bryozoa and an abundance of *Orthorhynchula linneyi* (Nettleroth).

Cat. No. 43,126, U. S. N. M.

Genus MONOTRYPELLA Ulrich

This genus should be restricted to the genotype, *M. æqualis* Ulrich, and such other ramose *Amplexoporidæ* as differ from *Amplexopora* only in wanting acanthopores. Of described species that have been referred to *Monotrypella,* it is doubtful if any but Edwards and Haime's *Monticulipora pulchella,* as redefined by Nicholson under the name *Monotrypa pulchella,* can maintain its position in this genus. The Devonian *Monotrypella simplex* Ulrich has amalgamated walls and must, therefore, be assigned to some other genus.

We are not yet prepared to name the genus to which *M. simplex* should be referred, nor even to decide definitely the family. In fact, aside from a species or two undoubtedly referable to *Batostomella* and the *Batostomella obliqua* Ulrich, in which we now see an *Eridotrypa,* the Devonian Trepostomata are very difficult to classify. Viewed collectively, they seem to form a group of Amalgamata by themselves, with varying relations to *Monticuliporidæ, Heterotrypidæ.* and *Batostomellidæ.* Studied individually, first one, then another of these relations seems to be the dominant one, with the result that closely allied species may be widely separated in their systematic arrangement. To secure a more natural and stable classification it is necessary to study the Devonian Trepostomata first as a whole and then no less carefully in connection with their Silurian progenitors. It is only in this way that we may hope to establish their genetic relations to the Ordovician types.

The genotype, *M. æqualis,* has given us much trouble. While the apparently total absence of acanthopores in the specimen from which the original figured set of thin sections was prepared, has been verified by another set of sections from the same, the lamentable fact remains that none of the numerous specimens hitherto believed to be of the same species is without them. After many failures to identify another specimen of the species, we have been forced to the conviction that the original type is unique. If it is not, then the specimen illustrates a wholly unparalleled abnormal condition of either preservation or structure. A fact opposed to the latter alternatives was brought out by a final comparison of the specimens involved in the question at issue, viz: of the hundreds of specimens of the new *Amplexopora* which, prior to our recent investigations, had been labeled as *M. æqualis,* not one had such broad monticules as the type specimen. Indeed, they cover as much or more space, and this despite the fact that they are lower than in any other type of Trepostomata known to us. The only species approaching or possibly equaling it in this respect is *Discotrypa elegans.* Difference merely in the height of monticules is usually of very little consequence, but the widening of their bases seems to indicate a structural difference, the interpretation of which involves the difficult question of the purposes of the "maculæ" themselves.

On account of the extreme rarity of the genotype, *Monotrypella* has been known to collectors only through the *M. quadrata* section of the genus. As the latter section constitutes a sharply defined natural group and deserves recognition as a distinct genus, we have decided to remove it under the following title and to allow *Monotrypella* either to stand or to fall with the species upon which it was originally based.

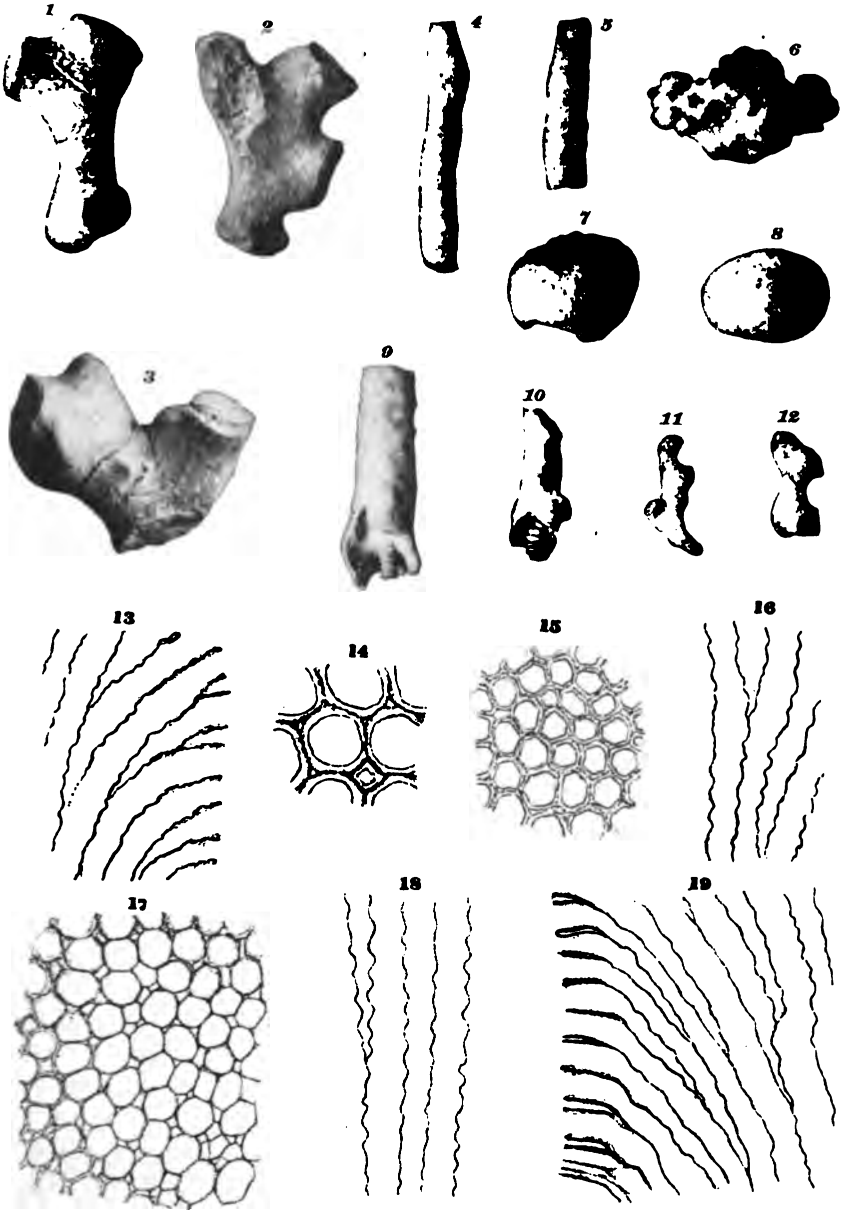
Genus RHOMBOTRYPA new genus

Generic diagnosis.—Ramose *Amplexoporidæ* with zoœcial tubes in axial region regularly quadrate or rhombic in cross-section. Acanthopores usually wanting, always shallow, rarely distinguishable internally. True mesopore absent, but wall-less tabulated interzoœcial spaces occur in several of the species.

Genotype.—*Monotrypella quadrata* (Rominger), a very abundant and one of the most characteristic and widely distributed fossils of the Richmond formation.

This group of species was recognized by Ulrich in 1890[1] when

[1] *Ill. Geol. Surv.*, vol. VIII, pp. 377, 452.



GENERA AND SPECIES OF TREPOSTOMATA

only three species, *M. quadrata* (Rominger), *M. subquadrata* Ulrich, and *M. crassimuralis* Ulrich, were known. Since that time another form, occurring like the others, in rocks of Richmond age, has been discovered. Finally, a fifth species was brought to light through the researches of Mr. Bassler on the bryozoa in the Niagaran Rochester shale of New York. The last species differs from the Richmond species in having acanthopores that may be distinguished in very shallow tangential sections of fully matured zoaria. In all the other species certain acanthopore-like spines, which often occupy the junction angles between the zoœcial apertures, leave no definite traces in the interior of the zoarium, so that, if they are really of the nature of acanthopores, neither their presence nor their nature is indicated by tangential sections.

The principal characteristic of the genus is the rhombic form of the axial tubes in cross-sections. In vertical fractures the axial region exhibits alternating smooth and uneven spaces. The smooth spaces represent the flat side of a row of tubes coinciding with the plane of the fracture. In the uneven spaces the angles and two sides of each of the tubes are exposed. In the latter case the plane of the sides of the tubes, and consequently of the rows, forms an angle of about 45 degrees with the plane of the fracture. This change in directions results from a periodic and simultaneous development of new tubes along the margins of those parts of the axial region in which the rows have the same direction. The interpolated new tubes maintain the triangular shape necessitated by the form of the spaces at their disposal until the next period of gemination causes another turn and the interpolation of another set of young tubes.

The development of new tubes ceases entirely with the entrance of the older tubes into the peripheral zone. This is true also of practically all other ramose Trepostomata, and as a rule it is only after the cessation of gemination that the increasing space at the disposal of the zoœcia, which naturally results from the peripheral growth in this zone, admits of the development of mesopores and acanthopores. In most cases, probably, the mesopores contained a specially modified kind of zooid, as did also the acanthopores, but when, as in the case of *Rhombotrypa,* the interzoœcial spaces have no walls of their own, it may well be doubted if they indicate a degree of dimorphism comparable with those cases in which true and fully developed mesopores occur. It may be admitted at once that it is often very difficult to decide whether these interspaces in a given case are true mesopores or not, but under all circumstances it is a point deserving more serious consideration than has yet been allotted to it.

The increasing space that is divided among the zoœcia as peripheral growth proceeds is variously employed in the complete development of ramose zoaria. In certain types, particularly simple Integrata, the normal width of the zoœcial cavity is maintained solely by deposits of laminated calcareous tissue on the inner sides of the walls. In other types the excess space is in a greater or less degree accounted for by triangular or quadrate open spaces left between adjoining zoœcia, and in these the deposit of tissue on the inner side of the walls is correspondingly thin. In other types, again, a part of the space is taken up by a thickening of the original walls in the process of their amalgamation. Finally, in the more complex Amalgamata, the normal width is maintained partly by the thickening incident to amalgamation, partly by deposit on the inner side, and partly by the development of acanthopores and mesopores.

In *Rhombotrypa quadrata* the excess space is taken up by deposit on the inner side of the walls, in *R. subquadrata* and *R. crassimuralis,* mostly in the same way but also by interzoœcial spaces, while in the undescribed Richmond and Niagaran species it is chiefly by such spaces.

The relative amount of excess space varies with three factors: (1) The diameter of the zoarium; (2) the width of the peripheral zone; and (3) the angle at which the tubes proceed to the surface after bending outward from the axial region. These in turn determine the thickness of the zoœcial walls at the periphery and the number of the mesopores. In a narrow branch the increase is proportionately more rapid than in a larger stem, in a wide peripheral zone the increase continues for a longer time, and when the zoœcial tubes turn abruptly into the peripheral zone and proceed in a direct line toward the surface the increase obviously is more rapid than when the angle is less abrupt. It has probably impressed others, as it has us, as a singular fact that ramose zoaria do not exceed a certain maximum diameter for each species. Primarily it is because no new zoœcia are developed after they have fully entered the peripheral zone. Next it depends upon a definite proportion between the respective sizes of the axial and peripheral zones. This proportion varies with the species, those with thin-walled zoœcia having a proportionally narrow outer zone or slowly curving tubes, and those with thick walls having a correspondingly wider peripheral zone. Finally, it depends upon the capacity of the zoœcia of a particular species to take care of the increase in space allotted to it as growth proceeds. When a certain limit, which varies with the species, is reached, growth must cease, and that part of the zoarium dies. But when through some irregularity in growth the normal increase is locally retarded, the zoœcia always continue to live until the limit of increase is reached.

Family CALLOPORIDÆ Ulrich

At present we have no change to suggest in this family nor in the definition of its genera, except a slight one in *Callopora*, that is made necessary by the erection of the following new genus upon *C. crenulata*, an untabulated species referred to that genus in 1893 by Ulrich. A new genus, agreeing, apparently, with *Callopora* in all respects except that is has indubitable acanthopores, is reserved for some future publication.

Genus CALLOPORINA new genus

Callopora (part.) ULRICH, 1893, Geol. Minn., III, p. 275.

Generic diagnosis.—Zoarium ramose or subramose; zoœcia polygonal to rounded with walls thin, iridescent, and crenulated in the axial region, slightly thickened and straight in the peripheral zone; mesopores few to numerous; diaphragms wanting in both zoœcia and mesopores; no acanthopores.

Genotype.—*Callopora crenulata* Ulrich, Black River and Trenton formations of Minnesota, Iowa, and Wisconsin.

The most obvious distinction between this new genus and *Callopora*, to which the genotype has heretofore been referred, lies in the total absence of diaphragms, not only in both regions of the zoœcial tubes, but also in the mesopores. Another character pertaining to all of the species so far observed is the decided crenulation of the zoœcial walls in the immature region. We have also observed, in all of the specimens of the various species examined, a very pretty appearance in vertical fractures. When such fractures are examined under a hand lens in a good light, a beautiful iridescence of the zoœcial tubes is seen. Of what importance this may be generically cannot be said, but as all of the species show this feature, we see no reason why it should not be included among the generic characters. That this iridescence has some structural significance is inferred from the fact that it does not occur in such other bryozoa with similarly crenulated walls as *Monotrypa undulata* and *Anaphragma mirabile*.

So far as known, the genus is limited to the Mohawkian group. *Anaphragma*, described in this paper, is a very similar new genus, but, having acanthopores, bears the same relation to *Batostoma* that *Calloporina* does to *Callopora*. *Calloporina crenulata* is rather abundant at a number of localities in the states mentioned above. *C. parva,* described below, occurred in considerable numbers in Tennessee and several additional new species are known to us from the Trenton rocks of Kentucky.

CALLOPORINA PARVA new species

(PLATE XIV, 13-16)

Zoarium small, ramose or subramose; branches cylindrical or compressed, 2 to 4 mm. wide, arising from an expanded base and not reaching a height of more than 20 or 30 mm. Surface smooth with inconspicuous maculæ. Zoœcial apertures angular, 9 to 10 in 2 mm. Mesopores small and rather few in number.

Vertical fractures show the crenulated walls and iridescence spoken of under the discussion of the genus. Thin sections show that the number of crenulations in a given space varies somewhat, but 16 in 2 mm. is a fair average. Diaphragms are as required for the genus, wanting in both zoœcia and mesopores.

Although agreeing in all essential internal characters with *Calloporina crenulata* (see plate XIV, 17–19), this species is readily distinguished. *C. crenulata* forms large, bushy masses, composed of strong, monticulated branches, with rounded zoœcia (8 in 2 mm.) and numerous small mesopores. *C. parva,* on the other hand, has a few narrow, smooth branches, containing smaller zoœcia and fewer mesopores.

Occurrence.—Abundant in a thin shaly bed of the age of the Black River formation, 2 miles south of Belfast, Marshall county, Tennessee.

Cat. No. 43,217, U. S. N. M.

Family TREMATOPORIDÆ Ulrich

We have paid some attention to the characters separating this family from the *Calloporidæ,* but as our investigations have not been completed, it is deemed unwise to express ourselves definitely at the present opportunity. We may say, however, that so far as we have gone, the published reasons for maintaining the *Trematoporidæ* have not been impaired. There are differences, when compared with *Calloporidæ*—in the development of the zoœcia, in the mesopores, and in the acanthopores—that require some recognition, and as now constituted there is little difficulty in separating the two families. At some future time we shall publish a new genus, represented by several species in the formations of the Stones River group in Tennessee, that may be succinctly described as a group of acanthopored

Calloporas. To what extent, if any, this new genus will affect the relations of the two families we are not prepared to say.

The following new genus necessitates a modification of our previous conception of the family to the extent of admitting untabulated zoœcia. Aside from the absence of diaphragms, the new type agrees very well with unquestionable species of *Batostoma.*

Genus ANAPHRAGMA new genus

Generic diagnosis.—Ramose *Trematoporidæ* agreeing in all essential respects with *Batostoma* Ulrich, except that both the zoœcial tubes and mesopores are entirely devoid of diaphragms.

Genotype.—*Anaphragma mirabile* new species, Richmond formation, Illinois and Wisconsin.

The specimens upon which this genus and species are founded were collected some years ago and laid aside under the belief that they belonged to a species of *Batostoma.* Though recognized as new, it appeared too near in its specific characters to certain already known species to make it worth while to work out its probably slight internal peculiarities. Subsequently, it became desirable to determine all our material from the Richmond at Wilmington, Illinois, so that this species came up for investigation with many others that had been laid aside for similar reasons. The total absence of diaphragms in the first set of thin sections was so unexpected that we were inclined to reject its evidence. When the same peculiarity was repeated in half a dozen other sets of sections, the features had to be accepted as an established fact.

We do not doubt that all will concede the generic value of this structural difference between *Batostoma* and *Anaphragma,* but some, possibly, may question the propriety of erecting the last-named genus and *Calloporina* upon practically the same peculiarity. The genus *Calloporina* is described on page 47. Critically examined, the latter group of species proves to be as intimately related to *Callopora,* and essentially in the same manner, as *Anaphragma* is to *Batostoma;* hence, if for any reason either of the new genera is united with the other, the same reason would apply with equal force in merging, not merely *Bastostoma* and *Callopora,* but their respective families as well.

ANAPHRAGMA MIRABILE new species

(PLATE XIII, 9–11)

Zoarium of smooth, strong, subcylindrical branches, 8 to 10 or more mm. in diameter, dividing rather frequently. Maculæ not a conspicuous feature; distinguished only by the size of their zoœcia, which are somewhat larger than the average. Zoœcial apertures, angular to subangular, with rather thick walls, 5 to 6 zoœcia in 2 mm.; mesopores small, and comparatively few in number; acanthopores small and seldom well shown at the surface, although when observed they show the usual apical perforation.

Internal characters.—In vertical sections the striking feature is the absence of diaphragms in both the zoœcia and mesopores. In the axial region the walls are thin and wavy, the crenulation being long and not so frequent as in species of *Calloporina*. With the inception of the mature region, the walls become greatly thickened and considerable laminated tissue is developed upon the inner sides. Tangential sections show the zoœcial walls to be of considerable thickness and to have the characteristic structure of *Batostoma*. The acanthopores are seen to be small, few in number, and situated at the junction angles.

The rather large angular zoœcia, thick walls, and few mesopores, and, more satisfactorily, the absence of diaphragms, distinguish this species from otherwise similar associated forms.

Occurrence.—Not uncommon in the Richmond formation at Wilmington, Illinois. Less abundant in the same strata at Delafield and Iron Ridge, Wisconsin.

Cat. Nos. 43,218, 43,219, U. S. N. M.

EXPLANATION OF PLATES

PLATE VI

Monticulipora mammulata D'Orbigny.............p. 16

FIGS. 1, 2. Vertical and tangential sections, × 20, of D'Orbigny's type.

3. Tangential section, × 35, illustrating the peculiar granulose structure.

Fairmount beds, Lorraine formation, Cincinnati, Ohio.

Monticulipora cleavelandi James................p. 16

4. Vertical section, × 20, showing the wall structure and distribution of cystiphragms and diaphragms.

5. Tangential section, × 20, through a part of the zoarium where the cystiphragms were not developed.

6. Tangential section of a zoœcium, × 35. The inner margin of the walls is unusually definite in this zoœcium.

Middle division of Richmond formation, Dutch creek, near Wilmington, Ohio.

Orbignyella sublamellosa new species..............p. 19

7. Tangential section, × 20.

8. Vertical section, × 20, passing through two layers of zoœcia.

9. Tangential section, × 40, showing the acanthopores and the wall structure with the white median line suggestive of the *Heterotrypidæ*.

Pierce limestone, Stones River formation, Murfreesboro, Tennessee.

Orbignyella lamellosa (Ulrich)..................p. 20

10. Tangential section of a single zoœcium, × 35. (Introduced for comparison.)

Richmond formation, Wilmington, Ill.

Prasopora patera new species..................p. 20

11. Tangential section, × 20, exhibiting the angular form and thin walls of the zoœcia and the comparatively few mesopores.
12. Vertical section, × 20, showing normal characters seen in such a section.
13. Vertical section, × 20, showing the superficial extremities of two zoœcial tubes and a case where the mesopores which occur further down in the section appear to have been crowded out.
14. Vertical section, × 20, showing a mesopore succeeded by a rapidly developing zoœcium.

Hermitage beds of the Trenton, 4 miles north of Columbia, Tennessee.

PLATE VII

Homotrypella nodosa new species................p. 21

FIG. 1. Vertical section, × 20.

2, 3. Tangential sections, × 20 and × 35, showing the thick, inflected walls and numerous acanthopores.

Leipers division of the Lorraine, Columbia, Tennessee.

Mesotrypa echinata new species................p. 22

4, 5. Tangential sections, × 20 and × 35, exhibiting the small angular zoœcia and large acanthopores.

6. Vertical section, × 20, passing through two mature regions with an immature zone between and showing the crowded diaphragms, which are characteristic of this species.

Lower part of the Catheys limestone of the Trenton, Nashville, Tennessee.

Mesotrypa angularis new species................p. 23

7. Tangential section, × 20. The large cells on the right belong to a macula, while those on the left are of ordinary zoœcia. The figure shows an average in the development of acanthopores, mesopores, and thickness of zoœcial walls.
8. A tangential section of an ordinary zoœcium, × 35.
9. A vertical section, × 20, with the mesopores limited to the immature (lower) region and the acanthopores strongest in the mature region.

Lexington limestone of the Trenton, Frankfort, Kentucky.

Dekayella foliacea new species.................p. 28

10. Tangential section, × 20, showing aged condition in which the walls are thickened, the mesopores reduced to a minimum, and the smaller set of acanthopores nearly obsolete.
11. Tangential section, × 35, exhibiting the normal development of the two sets of acanthopores.
12. Vertical section, × 20.

Lexington limestone of the Trenton, Lexington, Kentucky.

PLATE VIII

Cyphotrypa acervulosa (Ulrich)................p. 30

FIGS. 1, 2. Vertical sections, × 20, of the immature and mature regions respectively, showing variation in distribution of diaphragms in these two regions (from type sections figured by Ulrich).

3. Small portion of a tangential section, × 35, showing minute structure of walls and acanthopores in mature region.
Citambonites bed of Galena-Trenton, Decorah, Iowa.

Cyphotrypa wilmingtonensis new species............p. 31

4. Figure of a tangential section, × 20, illustrating the large acanthopores and thin walls.
5. Several zoœcia of the same tangential section, × 35.
6. Vertical section, × 20.
Richmond formation, Wilmington, Illinois.

Cyphotrypa frankfortensis new species.............p. 30

7, 8. Tangential section, × 20 and × 35.
9. Vertical section, × 20, showing distribution of diaphragms.
Top of Trenton formation, Frankfort, Kentucky.

Atactopora angularis new species................p. 32

10. Tangential section, × 20, showing a macula, the ordinary zoœcia, and the comparatively few acanthopores characterizing this species.
11. A portion of the same, × 35.
12. Vertical section, × 20, the central portion of the figure showing edge of a macula.
Lower beds of the Richmond formation, Waynesville, Ohio.

Atactopora maculata Ulrich..................p. 31

13. A zoœcium, × 35; drawn from the type section figured by Ulrich.
Fairmount beds, Lorraine formation, Covington, Kentucky.

Atactopora hirsuta Ulrich...................p. 31

14. Tangential section, × 35, of a zoœcium from the type section, introduced for comparison.
Utica formation, Covington, Kentucky.

PLATE IX

Stigmatella crenulata new genus and species. (See also plate XIV, 1, 2).p. 34

FIG. 1. Vertical section, × 20, exhibiting the crenulated walls of the immature region and the few thin diaphragms of the mature region.

2. Portion of a vertical section of mature region, × 35, exhibiting the periodic development of the acanthopores.
3. Tangential section, × 20, showing characters in a mature region.
4. A portion of the same, × 40. The figure contains a macula and illustrates the minute characters of the acanthopores and walls.
Lower beds of Richmond formation, Hanover, Ohio.

Stigmatella spinosa new species................p. 34

5. A tangential section, × 20, showing, as usual in the mature regions, abundant acanthopores and the almost total restriction of mesopores to the maculæ.
6. Small portion of same, × 40.
7. Vertical section, × 20, of mature region.

8. A portion of the same, × 50.
Richmond formation, Versailles, Indiana.

PLATE X

Stigmatella nicklesi new species. (See also plate XIV, 9, 10)....p. 36

FIG. 1. Vertical section, × 20. The lower curved line represents the outer surface of the crinoid stem over which the colony has grown, while the shaded portion above it represents a clay-filled interspace.

2. Tangential section, × 20, showing the very large and sharply defined acanthopores and thin zooecial walls.

3. Several zooecia of the same section, × 50.
Fairmount beds, Lorraine formation, Cincinnati, Ohio.

Stigmatella clavis (Ulrich)....................p. 34

4. Tangential section of several zooecia, × 50. Introduced for comparison with *S. nicklesi.*
Lower beds of Utica formation, Covington, Kentucky.

Stigmatella irregularis (Ulrich). (See also plate XIV, 6–8)....p. 34

5. Vertical section, × 20, illustrating the periodical development of the acanthopores and the extreme infrequency of the diaphragms.

6. Small part of a tangential section, × 40, where it passes through one of the zones of acanthopores. Ordinarily tangential sections show no acanthopores.
Fairmount beds, Lorraine formation, Hamilton, Ohio.

Stigmatella nana new species. (See also plate XIV, 11, 12).....p. 36

7. Ordinary aspect of tangential sections, × 20.

8. Portion of same, × 50.

9, 10. Vertical section, × 20, and portion of same, × 40.
Utica formation, West Covington, Kentucky.

Stigmatella dychei (James)....................p. 34

11. Vertical section, × 10, showing adaptation of zoarium to irregularity of the object grown upon.
Mt. Auburn beds of Lorraine formation, Lebanon, Ohio.

PLATE XI

Heterotrypa frondosa (D'Orbigny)................p. 25

FIGS. 1, 2. Tangential sections, × 35 and × 20, illustrating the wall structure and the distribution and character of the acanthopores and mesopores.

3. Vertical section, × 20, exhibiting the tabulation of zooecia and mesopores.
Sections prepared from the original of Edwards and Haime's figures of the species.
Lorraine formation, Cincinnati, Ohio.

Heterotrypa parvulipora new species..............p. 26

4, 5. Vertical and tangential sections, ×20. The almost total absence of mesopores is a noteworthy characteristic of this species.

6. A single zooecium, × 50, exhibiting the wall structure and acanthopores.

Catheys limestone of the Trenton, Love branch, Maury county, Tennessee.

Lioclema punctatum (Hall)..................p. 39

7, 8. Vertical and tangential sections, × 20, exhibiting the normal internal characters of the species.

9. Portion of figure 8, × 40, showing structure of walls and acanthopores.

Keokuk formation, Keokuk, Iowa.

Lioclema monroei new species.................p. 39

10. Vertical section, × 20.

11, 12. Tangential section, × 20 and × 35.

Hamilton formation, Bethany, New York.

PLATE XII

Stigmatella personata new species...............p. 35

FIG. 1. Tangential section, × 20, exhibiting the angular zoœcia, comparatively few and small acanthopores, and almost total absence of mesopores.

2. A portion of the mature region of a vertical section, × 20, showing the usual disposition of the diaphragms.

3. A zoœcium of fig. 1, × 50, showing structure of walls and acanthopores.

Lower beds of the Richmond formation, Hanover, Ohio.

Stigmatella interporosa new species...............p. 35

4. Tangential section, × 20, showing among other characters the abundance of mesopores characterizing this species.

5. Vertical section, × 20, showing the characters of the mature and immature regions.

Lower beds of the Richmond formation, Hanover, Ohio.

Lioclemella ohioensis (Foerste)................p. 39

6. Portion of an average tangential section, × 20, exhibiting characters deep in peripheral region. The zoœcia may be distinguished by having slightly thicker walls.

7. Vertical section, × 20, showing the turn from the axial to the peripheral region.

8. Several zoœcia of section of which fig. 6 represents another part, × 35.

9. Portion of another tangential section, × 35, exhibiting an extremely aged development of acanthopores.

Clinton formation, Dayton, Ohio.

Amplexopora filiosa (D'Orbigny)...............p. 41

10. Several zoœcia, × 35, as seen in the usual tangential section.

11. Tangential section of two zoœcia, × 35, showing the full development of acanthopores and the characteristic dark median line.

Lorraine formation, Hamilton, Ohio.

PLATE XIII

Amplexopora columbiana new species.............p. 41

FIG. 1. Tangential section, × 20, through a part of the zoarium where the acanthopores are best developed.

2. Ordinary aspect of tangential sections, × 20. The lower part of the figure shows the zooecia of a macula, and the upper those of the ordinary kind.
3. Vertical section, × 12, passing through an immature and mature region.
4. Vertical sections, × 12, passing through a macula and showing the funnel-shaped diaphragms which are more abundant than in the intermacular zooecia.
Leipers division of the Lorraine, Columbia, Tennessee.

Amplexopora cylindracea new species. (See also plate XIV, 4, 5)..p. 43

5, 6. Tangential and vertical sections, × 20.
Catheys division of the Trenton, Nashville, Tennessee.

Amplexopora ampla new species. (See also plate XIV, 3)......p. 42

7, 8. Tangential and vertical sections, × 20.
Leipers division of the Lorraine formation, Columbia, Tennessee.

Anaphragma mirabile new genus and species...........p. 49

9. Tangential section, × 20.
10. Vertical section of peripheral portion, × 20.
11. Vertical section of central part of axial region, × 20.
Richmond formation, Wilmington, Illinois.

Plate XIV

Stigmatella crenulata new genus and species. (See also plate IX, 1–4) p. 34

Figs. 1, 2. Natural size views of two fragments.
Richmond formation, Hanover, Ohio.

Amplexopora ampla new species. (See also plate XIII, 7, 8)....p. 42

3. Fragment of a zoarium, natural size.
Lorraine formation, Nashville, Tennessee.

Amplexopora cylindracea new species. (See also plate XIII, 5, 6)..p. 43

4, 5. Two specimens, natural size, showing the straight cylindrical form of the zoarial branches.
Trenton formation, Nashville, Tennessee.

Stigmatella irregularis (Ulrich). (See also plate X, 5, 6).....p. 34

6, 7, 8. Three zoaria, natural size, showing the variation of specimens from irregularly lobate nodose to smooth subglobose masses.
Lorraine formation, Hamilton, Ohio.

Stigmatella nicklesi new species. (See also plate X, 1–3).....p. 36

9, 10. Two nearly complete zoaria of the natural size.
Lorraine formation, Cincinnati, Ohio.

Stigmatella nana new species. (See also plate X, 7–10)......p. 36

11, 12. Fragments of natural size.
Utica shales, Covington, Kentucky.

Calloporina parva new species..................p. 48

13. Vertical section, × 20.
14. Tangential section, × 40, showing wall structure.
15. Tangential section, × 20.
16. Vertical section of immature region, × 20.
Black River formation, 2 miles south of Belfast, Tennessee.

Calloporina crenulata (Ulrich), new species...........p. 47

17, 18, 19. Tangential section, × 20, and vertical section of both regions, × 20, showing the internal characters upon which the new genus is founded. (After Ulrich.)
Black River formation, St. Paul, Minnesota.

ON NEW AND OLD MIDDLE DEVONIC CRINOIDS

By ELVIRA WOOD

The Devonic crinoids in the collection of the United States National Museum include a considerable number of unusually interesting specimens. Of these, two genera and seven species are new, while others show minor but noteworthy variations from forms already described.

These crinoids have been submitted to the writer for study through the courtesy of Mr. Charles Schuchert, Assistant Curator. It gives the writer pleasure, also, to acknowledge her indebtedness to Dr. Charles D. Walcott, in whose laboratory a portion of the work was done.

The specimens in the collection of the Massachusetts Institute of Technology were studied while the writer was connected with that institution.

The new forms, with one exception, are from the Traverse (Hamilton) formation of Michigan, and belong mainly to the genera *Megistocrinus* and *Dolatocrinus*. A single specimen from the Onondaga of New York appears to be referable to no described genus.

TRIPLEUROCRINUS n. gen.

τρί-, three; πλευρά, side; κρίνον, lily.

Dorsal cup including the patina only. Arms attached to a nearly circular facet on the outer surface of the radials. Arms unbranched and uniserial; composed of thick plates; ambulacral furrow deep; axial canal large. Column obscurely triangular, with one central and three smaller accessory canals.

Genotype.—Tripleurocrinus Levis n. sp.

This genus appears to be closely related to those of the family Gasterocomidæ so far as the parts preserved admit of comparison. The structure of the anal area, if known, might show a different relationship, but the genus may be referred provisionally to that family. It differs from the genus *Gasterocoma,* of the Devonic of Germany, and from other genera of the Gasterocomidæ in possessing a triangular column with three secondary canals instead of a four-angled column and four peripheral canals.

TRIPLEUROCRINUS LEVIS n. sp.

(PLATE XVI, 2, 2a.)

Description.—Body small, sides diverging at an angle of about 45°. Surface smooth. Infrabasals not observed, but their presence may be inferred from the truncated lower edge of the basals. Basals pentagonal. Only two of these plates are preserved on the single specimen found. Radials one-third larger than the basals, four-sided below, the upper portion of the plate curving inward and backward on either side to form a deep food groove. The structure of the anal area cannot be determined. Arm facets occupying two-thirds the width of the radials, and directed obliquely upward. Width of the arm plates about twice their thickness.

Plates of the column vary in size, every second or third plate being larger. The central canal is triangular in section, with three small circular canals opposite its sides and connected with it by short transverse canals (see pl. XVI, fig. 2*a*).

Formation and locality.—Onondaga limestone: Le Roy, New York.

Cat. No. 35,146 (holotype) U. S. N. M.

MEGISTOCRINUS Owen and Shumard

1852. OWEN AND SHUMARD, U. S. Geol. Rep't. Iowa, Wis., Minn., p. 594.

For abnormal calyx development see *M. sphæralis.*

MEGISTOCRINUS TUBERATUS n. sp.

(PLATE XV, 2, 2*a–c*. PLATE XVI, 3, 3*a*.)

Description.—This is a large crinoid with thick plates. The general form of the body is globular, with the base flattened to the middle of the first costals.

The center of each plate of the dorsal cup bears a large and extremely prominent node which may vary in shape from a broad cushion, covering nearly the whole surface of the plate, to a blunt wedge or a rounded knob. Some of the nodes, more particularly those on the radials, show a tendency to divide, forming a bi- or trituberculate crest. All these variations in form may be seen on the surface of a single individual. The entire surface of the dorsal cup is covered by extremely delicate, discontinuous ridges which radiate from the center of each plate, covering the nodes as well as the spaces between them, but interrupted at the suture lines between the plates (pl. xv, fig. 2*b*).

Basals three, the suture lines between them distinctly visible. The form, size, and relative position of the plates of a nearly complete individual are shown by the accompanying diagram (fig. 1). Arms sixteen, four in the anterior and postero-lateral rays, and two in each antero-lateral ray. A ray with four arms has usually one interdistichal, followed by two interpalmars placed side by side, but

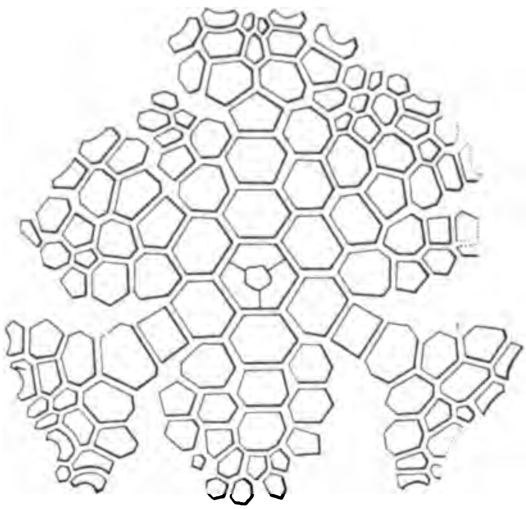


FIG. 1.—*Megistocrinus tuberatus* n. sp. Arrangement of calyx plates.

the number of these plates is not constant. The number of interbrachial plates beyond the second row is also variable, but there are commonly three plates in the third row with two in each succeeding row. The anal plate is similar in size and surface ornament to the radials. It is followed by three large plates in the second and four in the third row. Plates of the succeeding rows vary in number in different specimens, and are irregular in arrangement.

The tegmen is moderately convex, and but slightly depressed between the arm bases. It is formed of thick plates, large near the center, but small and very numerous toward the arm regions. The posterior oral is large and strongly spinose; the other orals are gently convex and but little larger than the neighboring plates of the tegmen. The radial dome plates bear stout spines. Anal tube subcentral.

Column circular in section, with large pentalobate canal.

Remarks.—This species of *Megistocrinus* differs from those already described in the presence of prominent nodes on all the plates of the calyx, in the form of the nodes, and in the delicate surface markings of the test. The specimen figured as the type of this species (pl. XV, 2, 2*a*) is incomplete, little more than half of the dorsal cup being present, but it is not compressed, and shows the form of the body and the surface markings extremely well. The diagram of the plates is from a more complete but badly distorted individual. On the surface of the latter specimen the delicate ridges have been entirely effaced, and the height of the tubercles considerably reduced by solution, but the suture lines between the plates are distinctly visible and the number and arrangement of the arms clearly indicated. The specimen from which the tegmen is drawn (pl. XV, 2*c*) is the largest specimen studied, and though somewhat crushed, measures approximately 45 mm. from the base to the posterior oral, and 53 mm. in greatest diameter. The calyx of a young individual is nearly complete. The full number of plates is present in the dorsal cup, and the surface nodes are unusually prominent. A slightly smaller specimen is abnormal in possessing but three arm openings in each of the postero-lateral rays. The space between the existing arm bases is, however, sufficient for two additional arms and their absence may be due to an injury received during the life of the crinoid. Figs. 3, 3*a*, pl. XVI, represent a very young specimen, measuring 9 mm. in height, and 11.5 mm. in diameter. In this the distichals are the highest plates of the dorsal cup, and the arm plates rest directly upon them. The arms are sixteen in number and arranged as in the adult. Tubercles on the surface are large and prominent, occupying nearly the whole surface of each plate. Plates of the tegmen are strongly convex, and three of the radial dome plates bear short spines.

Formation and locality.—Upper Traverse limestone: Partridge Point, south of Alpena, Michigan.

Cat. No. 26,395 (holotype and paratypes); 36,015 Rominger collection, U. S. N. M.

MEGISTOCRINUS REGULARIS n. sp.

(PLATE XV, 4, 4*a*.)

Description.—Dorsal cup low and broad; base flattened; sides straight, forming an angle with the base of about 60°.

Entire surface of the basals elevated. Radials often flat or even depressed at the center. Other plates of the dorsal cup strongly convex, or occasionally having the form of a low cone. Arms sixteen, four in the anterior and postero-lateral rays, two in the antero-lateral rays. Arrangement of calyx plates similar to that of other sixteen-armed species (see fig. 1). Arm bases rather small, forming a continuous row around the calyx, without interradial depressions.

Tegmen moderately elevated, not depressed between the arm bases, composed of numerous small, convex plates. The radial dome plates and a variable number of other tegmen plates bear short spines. Anal tube situated about one-third the distance from the center to the dorsal margin.

Column circular, with large, obscurely pentalobate canal.

Remarks.—This species is closely related to *Megistocrinus spinosulus* Lyon, but differs in having sixteen arms instead of forty, and the anal tube is less eccentric. The plates of the dorsal cup, though strongly convex, are less distinctly spinose. A single individual has seventeen arms, *i. e.,* three in the right antero-lateral ray, but as it is otherwise similar to eight specimens having sixteen arms, this may be regarded as an abnormal feature. The largest specimen studied measures 27 mm. in height, and 36 mm. in greatest diameter; the smallest is 15.5 mm. high, and 22 mm. in diameter.

Formation and locality.—Middle Traverse or Alpena limestone: Richard Collins' quarry,[1] Alpena, Michigan.

Cat. No. 36,013 (holotype), Rominger collection, and 35,144 U. S. N. M.

MEGISTOCRINUS SPHÆRALIS n. sp.

(PLATE XV, 1, 1*a–b*.)

Description.—Body nearly spherical in form, but slightly flattened at the base.

Surface of the basals elevated above the radials, forming a hexagonal plate which is nearly covered by the proximal plate of the column. Each plate of the dorsal cup, with the exception of the radials, bears a short spine. The radials may be ornamented by low ridges, or they may be smooth. Spines of the higher calyx plates cone-shaped, becoming more slender and longer as they approach the region of the arms.

Arms sixteen, arranged in a continuous row around the calyx, without interradial depressions. There are, as usual with this number of arms, four each in the anterior and postero-lateral rays, and two in the antero-lateral rays. The arm openings are large and vertical in position.

[1] Grabau, *Ann. Rep't Geol. Surv. of Mich. for 1901*, p. 176.

The arrangement of the plates of the calyx is shown by fig. 2; and fig. 3 shows the normal arrangement of plates in the anterior and upper portion of the calyx. It will be seen that this form differs from most species of *Megistocrinus* in including the lower plates of the biserial arms in the upper portion of the cup. As shown in the diagram (fig. 2) the type specimen appears to have but one costal in the left postero-lateral ray, but the specimen is broken, and this point cannot be determined with certainty.

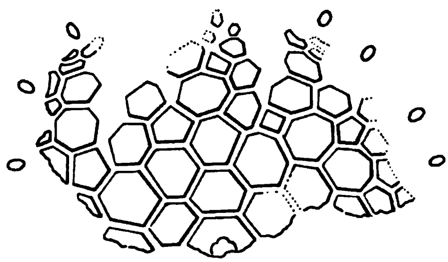


FIG. 2.—*Megistocrinus sphæralis* n. sp. An incomplete individual, the holotype.

Tegmen elevated, regularly dome-shaped, its plates small, smooth, or rarely spinose. The radial dome plates bear large spines. Anal tube slightly eccentric.

Column circular; canal large, and obscurely pentalobate.

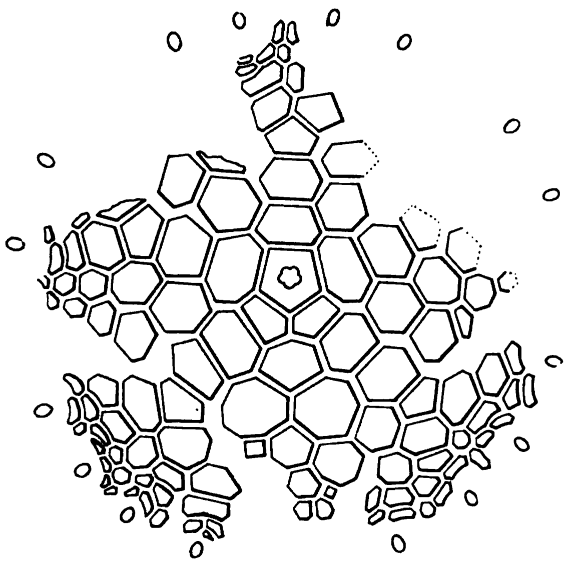


FIG. 3.—*Megistocrinus sphæralis* n. sp. Plates of the specimen represented by fig. 1*a*, pl. XV.

Remarks.—This species somewhat resembles *Megistocrinus nodosus* (Barris), but differs from it in the presence of spines on the higher plates of the calyx, and in the form of the tegmen which is more elevated than in the latter species and is not depressed in the interradial areas. From *M. tuberatus* n. sp. the present species differs in the pointed spines of the surface, the higher tegmen, and the absence of fine surface sculpture.

The type specimen is imperfect, only half the crinoid being present, as indicated by the diagram of its plates (fig. 2). The flattening of the base represented by fig. 1, pl. xv, is due to crushing. The base is normally but slightly flattened.

The large specimen represented by fig. 1*a*, pl. xv, closely resembles the type of *M. sphæralis,* and differs from it only in the arrangement of its posterior plates. In this respect the specimen is unique. The fused basals form a five-sided plate. The plates adjoining the basals on three sides are normal radials, and the structure of the crinoid in the anterior and antero-lateral rays does not differ from that of the type specimen so far as can be determined. Between the basals and radials of the postero-lateral rays are two small plates which, notwithstanding their position, appear to belong rather to the anal series than to the ray, since the otherwise normal ray is complete without them. These plates are without ornament, but resting upon them is a large plate ornamented like the radials. This plate is followed by two and four plates in the succeeding rows. The higher plates of the anal interray are few and small (see fig. 3). The whole number of plates in this area, thirteen, does not differ widely from that of the type which has about sixteen plates.

The arrangement of the calyx plates is considered of fundamental importance in the classification of crinoids, and upon such evidence alone this specimen would represent a new genus, but its close resemblance in other respects to three specimens undoubtedly of the genus *Megistocrinus* leads the writer to consider it an abnormal variation, and to place it, at least provisionally, with *M. sphæralis.* The development of such an abnormal individual may be accounted for if we imagine a bisection of the young anal plate, the halves of which, owing to some downward-acting force, grew laterally instead of vertically, and became intercalated between the adjacent basals and radials, while the middle plate of the second row moved downward until it came to lie wholly below its neighbors. The cause of such a downward acting force remains to be determined, but the tendency for higher plates to occupy lower positions in the calyx is shown, not only by such forms as *Tylocrinus novus* n. sp., described below, but by the inclusion of higher brachials within the calyx as in the Camerata.

Formation and locality.—Middle Traverse (Hamilton) or Alpena limestone: Richard Collins' quarry, Alpena, Michigan.

Cat. No. 26,397 (paratype), 26,398 (holotype and paratype), and 36,012 Rominger collection, U. S. N. M.

MEGISTOCRINUS ABNORMIS (Lyon)

(PLATE XV, 3)

1857. LYON. *Actinocrinus abnormis*, Geol. Rep. Ky., III, p. 479, pl. 4, figs. 1, 1*a*–*b*.

The statement is made by Wachsmuth and Springer[1] that this species is " devoid of ornamentation," and in the original description of the species no mention is made of the character of the surface ornament. An exceptionally well-preserved specimen of *Megistocrinus abnormis* (Lyon) from the Hamilton of Louisville, Ky., retains the surface ornament in a nearly perfect condition. This consists of fine ridges radiating from the center to the sides of each plate (pl. XV, fig. 3). The center of the plate is slightly depressed, and the ridges disappear in the region of the elevated and often truncated margin. This ornament suggests that of *M. depressus* (Hall), but differs in the absence of minute tubercles at the center of the plates. The ridges are also straighter and more regularly arranged.

Formation and locality.—Hamilton: Beargrass quarry and elsewhere about Louisville, Ky., Clark county, Ind., and Marion county, Ky.

Cat. No. 36,017 (Rominger collection), 42,429 (Ulrich collection), and 35,145 U. S. N. M. Also in Massachusetts Institute of Technology, No. 1,222.

MEGISTOCRINUS RUGOSUS Lyon and Casseday

1859. LYON and CASSEDAY, Amer. Jour. Sci. (2d ser.), XXVIII, p. 243.

A well-preserved individual of this species differs from the type in the structure of the anterior ray. In this the first interdistichal is a comparatively large plate, and is moved downward until it rests upon the truncated apex of the second costal. The first distichals are consequently widely separated. The interdistichal is followed by two plates, and these in turn by two minute interpalmars. The specimen corresponds with the type in other respects.

Wachsmuth and Springer[2] state in their description of *M. rugosus*, " Anal plate followed by rows of 4, 5, and 4 plates," etc. This description may have been written of an abnormal individual, for in

[1] *North American Crinoidea Camerata*, p. 546.

[2] Ibid., p. 543.

all the specimens studied, and in the type, according to the original description, there are but three plates following the anal plate.

Formation and locality.—Hamilton: Beargrass quarry, Louisville, Ky., and Clark county, Ind. Onondaga: Columbus, O.

Cat. No. 35,141, 36,019 (Rominger collection), and 43,154 (Ulrich collection), U. S. N. M. Also, No. 1,220, Massachusetts Institute of Technology.

MEGISTOCRINUS DEPRESSUS (Hall)

1862. HALL, 15th Rep. N. Y. State Cab. Nat. Hist., p. 134.
1895. *Megistocrinus ornatus* MILLER and GURLEY. Ill. State Museum of Nat. Hist., Bull. 7, p. 42, pl. II, figs. 15, 16, 17.

A comparison of the figures and descriptions of *M. depressus* (Hall) and *M. ornatus* M. and G. shows but slight differences between the two forms. The tegmen of the former is said to be "depressed" while that of the latter is "highly convex." In a series of specimens otherwise indistinguishable the height of the tegmen varies considerably, and the depressed tegmen may be due to mechanical pressure.

The base of *M. depressus* is said to be "flattened but not excavated," but specimens possessing all the other characteristics of the species have the base "a little concave below" as in *M. ornatus*. This certainly cannot be relied upon as a distinctive characteristic.

The only other difference recorded is in the absence of central nodes on the plates of *M. ornatus*, but as these nodes on *M. depressus* are extremely minute and easily worn away their absence is of little value as a distinguishing feature.

None of the differences noted appears sufficient for the separation of the species, and *M. ornatus* M. and G. becomes a synonym for *M. depressus* (Hall).

Formation and locality.—Hamilton: Louisville and Lebanon, Ky., and Charlestown, Ind. Onondaga: Columbus, O. Probably also in the Hamilton at Bartlett's Mills, near Thedford, Ontario.

Cat. No. 36,018 (Rominger collection), 42,430 and 42,433 (Ulrich collection), and 26,467 U. S. N. M. Also 1,224 Massachusetts Institute of Technology.

MEGISTOCRINUS FARNSWORTHI White

1876. WHITE, Proc. Acad. Nat. Sci. Phila., XXVIII, p. 29.

The specimens of this species are reported by their collector as rare fossils at the type locality.

Formation and locality.—Middle Devonic: Solon, Iowa.

Cat. No. 35,142.

MEGISTOCRINUS MULTIDECORATUS (Barris)

1885. *Megistrocrinus nodosus multidecoratus* BARRIS, Davenp. Acad. Nat. Sci., IV, p. 99, pl. II, figs. 3, 4.

This species is represented in the collection of the U. S. National Museum by several well-preserved individuals from the type locality.

Formation and locality.—Upper Traverse limestone: Partridge Point, Alpena, Michigan.

Cat. No. 36,021 U. S. N. M.

MEGISTOCRINUS NODOSUS Barris?

1878. BARRIS, Proc. Davenp. Acad. Nat. Sci., II, p. 285.

A large individual is referred with some doubt to *M. nodosus*. It differs from the type in the presence of nodes on the calyx plates above the first two rows, but the number of nodes on the surface of a crinoid is usually a variable feature.

The tegmen is slightly, not deeply depressed in the interradial areas.

The nodes on the upper calyx plates resemble those of *M. sphæralis* n. sp., but the tegmen is much flatter and is composed of smaller and more numerous plates.

A young individual measuring 11 mm. in height and 17 mm. in diameter is referred to this species on account of the flat tegmen and deeply indented interradial spaces.

Formation and locality.—Middle Traverse (Hamilton) limestone: Collins' quarry, Alpena, Mich. The species is first reported from the Middle Devonic of Davenport, Iowa.

Cat. No. 35,143 U. S. N. M.

MEGISTOCRINUS CONCAVUS Wachsmuth

1885. WACHSMUTH, Proc. Davenp. Acad. Nat. Sci., IV, p. 96, pl. I, figs. 5, 6, 7.

Formation and locality.—Upper Traverse limestone: Partridge Point, near Alpena, Michigan.

Cat. No. 36,016 (Rominger collection) U. S. N. M.

MEGISTOCRINUS SPINOSULUS Lyon

1861. LYON, Proc. Acad. Nat. Sci. Phila., p. 413, pl. IV, figs. 7*a*, *b*.

Formation and locality.—Onondaga: Columbus, O. Reported also from the Hamilton of Louisville, Ky.

Cat. No. 42,431 (Ulrich collection) U. S. N. M.

MEGISTOCRINUS EXPANSUS Miller and Gurley

1894. MILLER and GURLEY, Ill. State Museum of Nat. Hist., Bull. 4, p. 35, pl. III, figs. 18, 19, 20, 21.

A specimen in the collection of the U. S. National Museum resembles this species in form and general proportions. Some of the lower plates of the calyx are slightly elevated at the center, three or four of them sufficiently to form obscure nodes, but its correspondence with the type in this respect could not be determined as the surface of the latter is not preserved. This crinoid has lost two of its arms, evidently during the life of the animal, for the openings are covered by small, irregularly-shaped plates.

Formation and locality.—Middle Traverse limestone: Collins' quarry, Alpena, Mich. Hamilton: Clark county, Ind., and Louisville, Ky.

Cat. No. 36,014 (Rominger collection) U. S. N. M.

MEGISTOCRINUS LATUS Hall

1858. HALL, Geol. Rep't. Iowa, I, pt. II, p. 480.

Formation and locality.—Traverse (Hamilton): Petoskey, Mich. The type locality is at New Buffalo, Ia., in the Middle Devonic.

Cat. No. 36,020 (Rominger collection) U. S. N. M.

TYLOCRINUS n. gen.

(τύλος, a knob; κρινον, lily.)

Similar to *Megistocrinus* in form and general structure, but differing from it in the presence of numerous plates in the posterior interray, having two plates in the radial series and four in the second row. Two arms in the anterior and postero-lateral rays, and two or four in the antero-lateral rays. Of these characteristics, the arrangement of the arms and the large number of plates in the anal interray should be considered most important, as the presence of seven plates in the radial series may prove to be an abnormality.

Genotype.—*Tylocrinus novus* n. sp.

TYLOCRINUS NOVUS n. sp.

(PLATE XVI, 5, 5*a*.)

Description.—Calyx very small; base flattened; sides convex. The surface of each radial is ornamented by an elevated rim which follows the outline of the plate, and includes a depression at the center. Above the radials, each plate of the cup bears one (rarely two) prominent nodes which do not cover the whole plate. The surface of the plates between the nodes appears to have been ornamented by fine ridges similar to those of *Megistocrinus tuberatus* n. sp., but this feature is not well preserved.

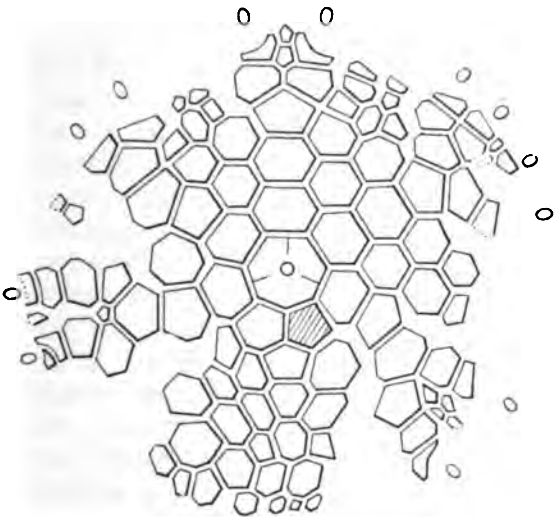


FIG. 4.—*Tylocrinus novus* n. gen. et sp. Arrangement of calyx plates.

Basals three; radials five; costals two times five. The right antero-lateral ray is the only one having four arms. In this the distichals bear on each axillary edge a first and second palmar. In the left antero-lateral ray there is only one distichal and but two palmars, though the second costal in this ray has the form of an axillary plate. The form of this plate seems to suggest the possible crowding out of the second distichal and the two arms required to make the right and left antero-lateral rays correspond in structure. Palmars are absent from the remaining three rays, the first distichal being followed by one or two additional distichals, and these by the two arms of the ray. The interbrachial formula is normally 1, 2, 3, 2, but in the left postero-lateral interray the brachial plates meet above the first interbrachial, probably a result of crowding due to the wide anal area. There are two minute interbrachials between the arm bases. A variable number of minute interdistichals or interpalmars are present in all but one of the rays.

The anal interray is peculiar in possessing two plates in the radial series. The formula for the succeeding rows of plates is 4, 4, 5, 4, 7. The plates of the sixth row merge into those of the tegmen.

Tegmen moderately elevated and formed of minute, strongly convex plates. Anal tube subcentral.

Column circular with minute canal. The single specimen found measures 10 mm. in height and 13 mm. in greatest diameter.

Remarks.—In this specimen the presence of two plates in the radial series of the anal interray is a remarkable feature, and were that the only variation from a normal *Megistocrinus* it might be considered an abnormality, but the plates of the anal interray are more numerous than in *Megistocrinus,* there being twenty-six plates in this specimen as compared with seventeen in *Megistocrinus tuberatus* n. sp., the species to which this is most nearly related, and the latter is four times as large as *Tylocrinus novus.* It might also appear that the wide posterior area is due to some accident which has displaced the left posterior arms, and crowded out the adjacent interbrachials and brachials, were it not that the elimination of calyx plates begins only above the first interbrachial while the widening of the anal interray begins in the radial series. Some difference in the size or arrangement of the internal organs may have caused a widening of the posterior area, necessitating the growth of more plates to cover this portion of the body. The crowding out of lateral plates would thus be a result and not a cause of the wide posterior area.

Of the two posterior plates in the radial series the left is ornamented like the radials with an elevated rim and central depression, while the right bears a node like those of the higher calyx plates. This fact seems to indicate that the right is the true anal plate, and the left is a higher interbrachial which has moved downward to its present position.

Whatever the cause of the variation, the present species possesses, in addition to the single extra plate in the radial series, a large number of well developed and regularly arranged posterior plates, whose presence has affected in a marked degree other structures of the calyx. Moreover, if two of the arms have been lost by crowding, as the structure of the left antero-lateral ray indicates, this species was derived from a form having four arms in each of the antero-lateral rays and two in the others, the reverse of the arrangement common in *Megistocrinus,* of two arms in the antero-lateral rays and four in the other three rays. Such important structural differences from *Megistocrinus,* its nearest ally, seem to entitle this form to rank as the type of a distinct genus, of which *Tylocrinus novus* is the only known species.

Formation and locality.—Upper Traverse limestone: Partridge Point, near Alpena, Mich.

Cat. No. 35,150 U. S. N. M.

DOLATOCRINUS Lyon

1857. Lyon, Geol. Rep't Kentucky, III, p. 482.

The number and arrangement of the arms has long been considered of fundamental importance for the separation of species in the genus *Dolatocrinus*, but the present study has led the writer to regard this feature as of less value for purposes of classification. Some of the reasons which have led to this view are as follows: We find individuals of the genus which would be referred to the same species except for differences in the number of the arms. The differences in the arms vary in degree from a slightly unlike arrangement to wide variation in both number and arrangement. For example, specimen No. 672 in the collection of the Massachusetts Institute of Technology has the arm formula[1] 2–1 . . . 2–2 . . . 2–1 . . . 2–2 . . . 2–2, while that of *Dolatocrinus venustus* M. and G., which it otherwise resembles, is 1–2 . . . 2–2 . . . 1–2 . . . 2–2 . . . 2–2. Another specimen in the same collection, identified as *D. greenei*, has the following arm formula: 2–2 . . . 2–2 . . . 2–1 . . . 2–2 . . . 2–2. The formula for the type is 2–1 . . . 2–2 . . . 2–2 . . . 2–2 . . . 2–2, from which it will be seen that the two specimens differ only in the grouping of the arms with reference to the anterior ray.

Differences in the number of arms are illustrated by *D. triadactylus* Barris and *D. hammelli* M. and G. The former has three arms to the ray (1–2 . . . 2–1 . . . 1–2 . . . 2–1 . . . 1–2), and the latter one more arm, thus, 1–2 . . . 2–1 . . . 2–1 . . . 2–1 . . . 2–2. A similar difference exists between *D. salebrosus* (see below) and a specimen which has been referred to that species.

So far as can be determined from the figures and descriptions, *D. bellulus* M. and G. differs from *D. nodosus* M. and G., and *D. aspratilis* M. and G. from *D. argutus* M. and G. only in the presence of one additional arm. A greater difference is shown by *D. sacculus* M. and G. and *D. salebrosus* M. and G. The former has four arms to each ray while the arm formula for the latter is 2–2 . . . 2–2 . . . 1–2 . . . 1–1 . . . 1–2; yet the two are closely related if not identical forms. The great variation in the number of arms in this genus is further illustrated by the occasional presence of a fifth arm in one ray as in *D. neglectus* M. and G. The arms are arranged as follows: 1–2 . . . 2–1 . . . 2–3 . . . 2–1 . . . 1–2. It is believed that a comparison of the type specimens would furnish many illustrations of this

[1] The arm formulæ used in this paper represent the number of arms beginning with the anterior ray and passing from left to right around the tegmen. The halves of a ray are separated by a hyphen, and adjacent rays by a row of dots.

kind, but the evidence at hand seems sufficient to show that the number of arms is of value when taken in connection with the other features, yet it cannot be relied upon as the sole characteristic by which species are to be distinguished.

Wachsmuth and Springer[1] have noted that the number of arms cannot be used for specific separation in the genus *Dizygocrinus,* and this appears to be true also of *Dolatocrinus.*

DOLATOCRINUS COSTATUS n. sp.

(PLATE XVI, 6, 6*a*.)

Description.—This is a large species with a low dorsal cup about two and one-half times as broad as high. Base deeply indented, the depression including all, or nearly all, of the radials. The sides of the dorsal cup bend abruptly upward and stand at right angles to the base. They are slightly constricted below the arm bases.

The surface is ornamented by thick, somewhat irregular ridges diverging from the center of each plate to the middle of its sides. The center of the first interbrachial is marked by a circular pit, or depression, from which the ridges pass to the sides of the plate. Distinct nodes appear to be absent from the surface, though the center of a plate may be elevated by the intersection of the strong ribs. Suture lines between the plates depressed.

Basals not observed. Radials five; costals two times five; distichals one time ten; palmars two times twenty. The first interbrachial is the largest plate of the calyx, and is succeeded by two small plates placed one above the other. A variable number of minute interpalmars is between or just below the arm bases. Arm openings four to the ray and vertical in position. Interradial and interbrachial pores four to six. Calyx slightly indented between the rays.

Tegmen but slightly elevated, its plates large and smooth with beveled edges. Anal tube subcentral. The surface of the tegmen is slightly depressed between each pair of arms, the interradial depressions being deeper than the others.

Remarks.—This species is most nearly related to *D. icosidactylus* Wachsmuth and Springer, from which it differs in the flatter tegmen with its smooth surface and faint interradial depressions, the absence of nodes on the surface of the dorsal cup, and the deeper basal excavation.

Formation and locality.—Middle Traverse or Alpena limestone: Collins' quarry, Alpena, Mich.

Cat. No. 26,396 U. S. N. M.

---

[1] *North American Crinoidea Camerata,* p. 414.

DOLATOCRINUS ASTERIAS n. sp.

(PLATE XVI, 1, 1a.)

Description.—Dorsal cup low and broad; sides vertical, base flattened, with a deep and narrow basal indentation which includes a little more than half of the radials. Plates very thick, with the suture lines usually deeply impressed, though this is a variable feature, and in some specimens the depressions are not strongly marked.

Surface highly ornamented. In the most typical specimens the ornament consists of sharply elevated ridges which pass from the center of each plate to the middle of its sides. These ridges are stronger on the radials and first interbrachials, forming a star-shaped figure whose points are at the middle of the interbrachials. At these

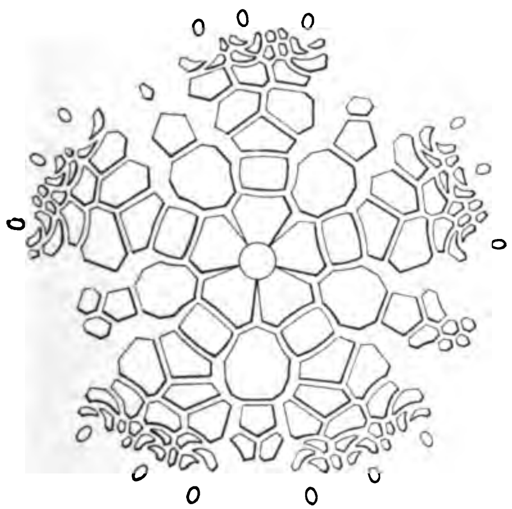


FIG. 5.—*Dolatocrinus asterias* n. sp. Arrangement of calyx plates.

points there is usually a circular depression, though occasionally a low node replaces the depression. Other ridges from the center of the radials outline the basal depression, forming a five-sided rim around it. The ridges of the higher calyx plates are nearly as distinct as those of the radials and first interbrachials. The ornament of the surface, while always strongly marked in well-preserved specimens, varies considerably in general appearance on different individuals. On some specimens the center of each plate, where the ridges intersect, is elevated, giving the surface a nodose rather than a ribbed appearance. These varieties of ornament are readily seen to belong to the same type, the differences being dependent mainly on the relative amount of material deposited at the intersections or throughout the length of the ridges, and also upon the strength of the sutural depressions. The specimens studied form a series connecting the extreme types of ornament by insensible gradations.

The arrangement of the calyx plates is shown in the accompanying diagram, fig. 5.

Arms fifteen, three to the ray. The arm bases are large, and the openings are directed obliquely upward. Interradial pores three, with one or two between adjacent brachia.

Tegmen slightly elevated, composed of thick, rugose plates with deeply sunken suture lines. The anal tube is nearly central in position.

Column small, circular, with pentalobate canal.

Remarks.—This species somewhat resembles the preceding in surface ornament, but differs from it in size, in the number of arms and

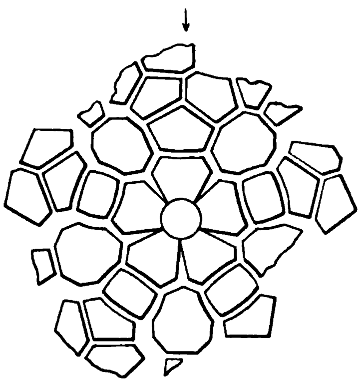


FIG. 6.—Plates of an abnormal individual of *Dolatocrinus asterias* n. sp.

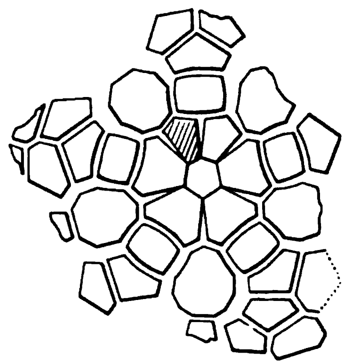


FIG. 7.—Plates of an abnormal individual of *Dolatocrinus asterias* n. sp.

respiratory pores, and in the direction of the arms as they leave the body. The basal depression is deeper, narrower, and more definitely outlined. The tegmen of this species differs widely from that of *Dolatocrinus costatus* n. sp., both in its more convex form and in its small, elevated, and rugose plates.

Among those referred to this species are two incomplete specimens which are abnormal in the number of their calyx plates. The specimen from which fig. 6 was drawn retains the characteristic surface ornament of *D. asterias* n. sp., and differs from the type only in the absence of one costal, as represented in the diagram. A young specimen also showing the characteristic form and ornament of this species is unique in possessing six plates in the radial series. The plates of this specimen are represented, so far as they are preserved, by fig. 7. It is believed that both these specimens represent abnormal variations, since the absence of a single plate in one case, and the presence of an extra plate in the other, are the only means by which they can be distinguished from thirteen normal specimens with which they have been compared.

Formation and locality.—Alpena limestone, and Upper Traverse limestone: Richard Collins' quarry, Alpena, and Partridge Point, near Alpena, Mich.

Cat. No. 36,022–23 (Rominger collection), and 35,140 U. S. N. M.

DOLATOCRINUS sp.

A crinoid from the Hamilton of Louisville, Ky., is represented by a mold of the lower portion of the interior only, but the suture lines between the plates are distinctly shown, and faint ridges are present which probably indicate the position of ridges on the outer surface of the crinoid (see fig. 8). The specimen is referred to *Dolatocrinus* as an abnormal individual, since a similar variation occurs in an individual which may, with little doubt, be referred to *Dolatocrinus asterias* n. sp. (compare fig. 7). The fine lines on fig. 8 represent the faint ridges above referred to. These seem to strengthen the evidence in favor of placing the specimen with the genus *Dolatocrinus*. It is too imperfect for specific identification.

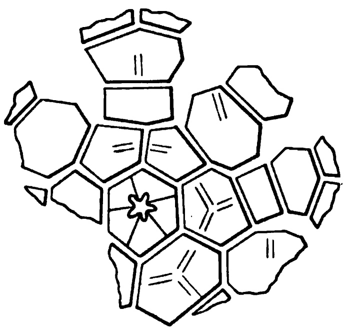


FIG. 8.—*Dolatocrinus* sp. Arrangement of plates.

Cat. No. 36,027 (Rominger collection) U. S. N. M.

DOLATOCRINUS LACUS Lyon

1857. LYON, Geol. Rep't Kentucky, III, p. 482, pl. IV, figs. 2, 2*a*–*c*.

Formation and locality.—Onondaga: Columbus and Dublin, O. Hamilton: Charlestown, Ind. The type locality is in the limestone bed above the "Black Slate," Louisville, Ky.

Cat. No. 36,025 (Rominger collection), 43,107 and 43,109 (Ulrich collection) U. S. N. M. Also in Massachusetts Institute of Technology, No. 654.

DOLATOCRINUS GREENEI Miller and Gurley

1894. MILLER and GURLEY, Ill. State Museum of Nat. Hist., Bull. 4, p. 28, pl. III, figs. 10, 11, 12.

The original description of *Dolatocrinus greenei* mentions the occurrence, in two of the interradial areas, of two plates in the first row of interbrachials. These could not be made out with certainty in any of the specimens examined, but a specimen from Louisville, Kentucky, has one interradial area much wider than the others and wide enough for two plates. Another specimen referred to *D. greenei* agrees with the description and figure of that species except that the interradial areas are alike in possessing but one first interbrachial. There is also, as noted above, a slight difference in the grouping of the arms with reference to the anterior ray. The occurrence of additional interbrachials in the type may be abnormal, as suggested by the authors of the species.

Formation and locality.—Hamilton (?): Louisville, Ky., and Charlestown, Ind. Apparently also in the Onondaga near Dublin, Ohio.

Cat. No. 35,139 and 43,108 (Ulrich collection) U. S. N. M. Also in Massachusetts Institute of Technology, No. 655.

DOLATOCRINUS CHARLESTOWNENSIS Miller and Gurley

1896. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 8, p. 44, pl. III, figs. 10, 11, 12.

A specimen lacking the surface ornament, hence with some doubt referred to *D. charlestownensis* Miller and Gurley, apparently differs from it only in having two instead of three arms in one of the rays. Another specimen in the collection of the Massachusetts Institute of Technology shows the characteristic features of the species.

Formation and locality.—Hamilton: Thedford, Ontario, and Charlestown, Ind.

Cat. No. 26,466 U. S. N. M. Also No. 652 Massachusetts Institute of Technology.

DOLATOCRINUS TRIADACTYLUS Barris

1884. BARRIS, Proc. Davenp. Acad. Nat. Sci., IV, p. 100, pl. II, figs. 5, 6, 7.

1896. *Dolatocrinus aplatus* MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 8, p. 48, pl. III, figs. 16, 17, 18.

This species is represented in the National Museum collection by several well-preserved specimens. A comparison of the figures and descriptions of *D. triadactylus* and *D. aplatus* shows a close correspondence between the two. The chief difference appears to be in the number of upper brachial plates in the dorsal cup. *D. triadactylus* is said to have on one side of each ray two distichals and on the other one distichal bearing on each upper edge a single palmar, while *D. aplatus* has four distichals on one side of the ray with one distichal on the other side followed by four palmars on each of its upper edges. The specimens in the collection of the National Museum are all from the type locality of *D. triadactylus,* yet they agree in the number of brachial plates with *D. aplatus* which is from Charlestown, Indiana. An incomplete specimen from the latter locality also agrees with those from Alpena so far as it is preserved. The smaller number of distichals and palmars reported for *D. triadactylus* may perhaps be accounted for by the fact that the arms are biserial above the first palmars and the small wedge-shaped plates may have been counted by the author of the species as arm plates. On the other hand the fact that these plates are incorporated into the calyx has led Miller and Gurley to count them as calyx plates.

Respiratory pores have not hitherto been reported for *D. triadactylus,* but well-preserved material reveals their presence to the number of thirty or more. There seem to be no constant characteristics which separate this species from *D. aplatus,* and the latter becomes a synonym for *D. triadactylus.*

Formation and locality.—Upper Traverse limestone: Partridge Point, near Alpena, Mich. Hamilton: Charlestown, Ind.

Cat. No. 36,024 (Rominger collection), and 26,394 U. S. N. M. Also in Massachusetts Institute of Technology, No. 651.

DOLATOCRINUS HAMMELLI Miller and Gurley

1895. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 6, p. 52, pl. 5, figs. 4, 5, 6.

The chief difference between this species and *Dolatocrinus triadactylus* appears to consist in the presence of one additional arm in *D. hammelli,* the arm formula being 1–2 . . . 2–1 . . . 2–1 . . . 2–1 . . . 2–2. Further study may show that they constitute one species, but with the incomplete material at hand their identity could not be determined.

Formation and locality.—Hamilton: Near Charlestown, Ind.

Cat. No. 653 Massachusetts Institute of Technology.

DOLATOCRINUS MAJOR Wachsmuth and Springer

1897. WACHSMUTH and SPRINGER, North Amer. Crinoidea Camerata, p. 322, pl. XXV, fig. 5.

A large specimen from Columbus, Ohio, is of this species. The figure of the type specimen shows two or three plates in the second row of interbrachials, while the description reads: "The plate of the second row is approximately as large as the first costal, but higher than wide and hexagonal." In this respect the National Museum specimen agrees with the description.

Formation and locality.—Onondaga: Price's quarry, Columbus, O.; Falls of the Ohio.

Cat. No. 42,428 (Ulrich collection) U. S. N. M.

DOLATOCRINUS GLYPTUS (Hall)

1862. *Cacabocrinus glyptus* HALL, 15th Rep't New York State Cab. Nat. Hist., p. 140.

Formation and locality.—Onondaga: Dublin, O. Hamilton: Beargrass creek, Louisville, Ky. The species is reported from Columbus, Ohio; Hamilton (Livingston county), and Pavilion (Genesee county), New York.

Cat. No. 42,410 and 42,432 (Ulrich collection) U. S. N. M.

DOLATOCRINUS ORNATUS Meek

1871. MEEK, Proc. Acad. Nat. Sci., Phila., p. 57.

This species is regarded by Wachsmuth and Springer as a synonym for *Dolatocrinus glyptus* (Hall), but the specimens in the collection of the National Museum do not seem to warrant such a reference. They agree perfectly with the original description of *D. ornatus* while differing widely from that of *D. glyptus*. The surface of the latter, as shown by the figures of Wachsmuth and Springer,[1] bears a few short, discontinuous ridges, or according to the original description, "lines of nodes," while that of *D. ornatus*, as it appears on the surface of an exquisitely preserved specimen, is closely covered with thin, sharp carinæ which are continuous from the center of one plate to that of its neighbor. Distinct nodes, if present at all, are not a characteristic feature of the ornament. The base of *D. ornatus* is deeply indented, the depression including about one-third of the radials. That of *D. glyptus* is flat.

No figure accompanies the original description of *D. ornatus*, but

[1] *North American Crinoidea Camerata*, pl. XXVI, figs. 2*a*, *b*.

the specimens studied agree with Miller and Gurley's figure of that species in the Illinois State Museum Nat. Hist., Bulletin 4, pl. II, figs. 7, 8, 9. This figure differs widely from that of *D. glyptus* referred to above. It appears, therefore, that *D. ornatus* Meek should stand as a valid species.

Formation and locality.—Onondaga: Columbus, O. A few plates from the Hamilton, at Beargrass creek, Ky., have a similar surface ornament and are referred with doubt to this species.

Cat. No. 42,427 and 43,110 (Ulrich collection) U. S. N. M.

DOLATOCRINUS CÆLATUS Miller and Gurley (?)

1896. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 8, p. 46, pl. III, figs. 13, 14, 15.

A small nodose individual is referred to this species with doubt since the upper part of the calyx is not sufficiently preserved to show the number of arms.

Formation and locality.—Onondaga: Dublin, O. Reported from Charlestown and Speed's quarry, Clark county, Ind.

Cat. No. 42,434 (Ulrich collection) U. S. N. M.

DOLATOCRINUS INDIANENSIS Miller and Gurley (?)

1896. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 8, p. 40, pl. III, figs. 1, 2, 3.

Two imperfect individuals are referred with doubt to this species.

Formation and locality.—Louisville, Ky. The type locality is Hamilton, near Charlestown, Ind.

Cat. No. 36,028 (Rominger collection) U. S. N. M.

DOLATOCRINUS WACHSMUTHI n. nom.

1897. Dolatocrinus lyoni WACHSMUTH and SPRINGER (name preoccupied by Miller and Gurley). North Amer. Crinoidea Camerata, p. 314, pl. XXV, figs. *6a, b, c, d.*

A specimen in the collection of the Massachusetts Institute of Technology has been referred to *Dolatocrinus lyoni* Wachsmuth and Springer, but the specific name *lyoni* was given by Miller and Gurley in 1896[1] to a widely different species. As the "North American Crinoidea Camerata" did not appear until 1897, Miller and Gurley's name has priority. It is here proposed to name the present species for one of its distinguished describers.

This species is closely related to *D. amplus* Miller and Gurley, but the latter has four arms in each ray instead of three to the ray

[1] *Ill. State Museum Nat. Hist., Bull. 9*, p. 44, pl. III, figs. 4, 5, 6.

as in *D. wachsmuthi*. Such a wide difference in the number of arms may indicate a difference in species. There are also slight differences in the surface ornament.

Formation and locality.—Hamilton: Charlestown, Ind.

Cat. No. 624 M. I. T.

DOLATOCRINUS AMPLUS Miller and Gurley

1894. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 5, p. 45, pl. IV, figs. 6, 7, 8.

Formation and locality.—Hamilton: Charlestown, Ind.

Cat. No. 650 M. I. T.

DOLATOCRINUS SALEBROSUS Miller and Gurley

1895. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 7, p. 59, pl. III, figs. 13, 14, 15.

A well-preserved specimen differs from *Dolatocrinus salebrosus* mainly in possessing an additional arm. The structure of the two-armed ray in the type specimen of *D. salebrosus* is like that of a three-armed ray as far as the top of the first distichals, beyond which the additional distichals and the arm are lacking from one side of the ray. The normal structure of this ray is probably represented by a three-armed ray, as in the specimen under consideration. The arm formula for the latter is 1–2 . . . 2–2 . . . 2–2 . . . 1–2 . . . 2–1, and that of *D. salebrosus* 2–2 . . . 1–2 . . . 1–1 . . . 1–2 . . . 2–2, from which it will be seen that there is a difference in the arrangement of the arms with reference to the anterior ray, but, as noted above, this feature, in the genus *Dolatocrinus,* cannot be considered of value for specific determination.

The presence of respiratory pores has not been determined for the type, but they are plainly visible in the specimen studied.

Formation and locality.—Hamilton: Charlestown, Ind.

Cat. No. 656 M. I. T.

DOLATOCRINUS EXCAVATUS Wachsmuth and Springer

1897. WACHSMUTH and SPRINGER, North Amer. Crinoidea Camerata, p. 321, pl. XXV, fig. 1; pl. XXXVI, figs. 7, 8.

An individual retaining the lower portion of the dorsal cup only, has been identified with this species. The species is closely related if not identical with *D. grandis* Miller and Gurley. The chief difference seems to be the presence of sharp carinæ on the lower brachial plates of *D. excavatus*. These are not mentioned in connection with *D. grandis,* but the basal depression of the type of that species is filled with the matrix which may conceal this feature. Other slight differences have been noted in the number of respiratory pores and the number of higher interbrachial plates, but these may be due to differences in the age of the individuals compared. It is thought best, however, to retain *D. excavatus* as a distinct species until further evidence can be obtained from specimens.

Formation and locality.—Hamilton: Falls of the Ohio. Reported from Clark county, Ind.

Cat. No. 658 M. I. T., also 36,029 (Rominger collection) U. S. N. M.

DOLATOCRINUS GRANDIS Miller and Gurley

1894. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 4, p. 14, pl. II, figs. 1, 2, 3.

A well-preserved tegmen has been referred to this species. The dorsal cup is not preserved, hence comparison could not be made with the specimen of *D. excavatus* to determine if they belong to the same species.

Formation and locality.—Hamilton(?): Falls of the Ohio.

Cat. No. 657 M. I. T.; also 36,026 (Rominger collection) U. S. N. M.

DOLATOCRINUS VENUSTUS Miller and Gurley

1894. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 4, p. 23, pl. II, figs. 16, 17, 18.

A large individual differs from the type in the arrangement of the arms as described under the genus *Dolatocrinus,* but this feature is of little value for the identification of species.

Formation and locality.—Hamilton: Clark county, Ind.

Cat. No. 672 M. I. T.

DOLATOCRINUS PULCHELLUS Miller and Gurley

1895. MILLER and GURLEY, Ill. State Museum of Nat. Hist., Bull. 6, p. 55, pl. V, figs. 13, 14, 15.

Formation and locality.—Hamilton: Charlestown, Ind.

Cat. No. 1,228 M. I. T.

STEREOCRINUS Barris

1878. BARRIS, Proc. Davenport Acad. Nat. Sci., II, p. 282.

STEREOCRINUS BARRISI Wachsmuth and Springer

1897. WACHSMUTH and SPRINGER, North Amer. Crinoidea Camerata, p. 326, pl. XXV, figs. 9*a*, *b*.

This species is represented in the National Museum collection by many large and well-preserved specimens.

Formation and locality.—Upper Traverse limestone: Partridge Point near Alpena, Mich.

Cat. No. 36,031 (Rominger coll.) U. S. N. M.

GENNÆOCRINUS Wachsmuth and Springer

1881. WACHSMUTH and SPRINGER, Revision Palæocr., pt. II, p. 160 (Proc. Acad. Nat. Sci. Phila., p. 334).

GENNÆOCRINUS KENTUCKIENSIS (Shumard)

1866. *Actinocrinus kentuckiensis* SHUMARD, Trans. Acad. Sci. St. Louis, II, p. 345.

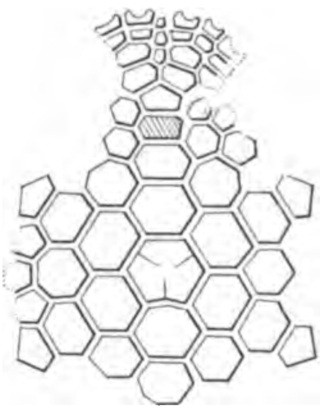


FIG. 9.—*Gennæocrinus kentuckiensis* (SHUMARD). Plates of an abnormal individual.

A somewhat imperfect specimen differs from *Gennæocrinus kentuckiensis* only in the presence of three costals in the anterior ray. The position and relative size of the plates, so far as they can be determined from the specimen, are shown by fig. 9. Although the genus *Gennæocrinus* is characterized by great regularity in the arrangement of the plates, the presence of a single extra costal does not seem sufficient ground for a separation of the specimen from it, and this may be regarded as an instance of abnormality occurring in a genus different from those already noted.

Formation and locality.—Hamilton: Beargrass quarry, Louisville, Ky.

Cat. No. 35,149 U. S. N. M.

GENNÆOCRINUS CARINATUS Wood

1901. WOOD, Amer. Jour. of Sci., ser. 4, XII, p. 297, pl. V, figs. *a*, *b*, *c*.

The collection of the Mass. Institute of Technology contains the type specimen of this species and a young individual which differs from the type in unimportant details of the surface ornament only.

Formation and locality.—Hamilton: Charlestown, Ind.

Cat. No. 1,229 M. I. T.

GILBERTSOCRINUS Phillips

1836. PHILLIPS, Geology of Yorkshire, p. 207.

GILBERTSOCRINUS INDIANENSIS Miller and Gurley

1895. MILLER and GURLEY, Ill. State Museum Nat. Hist., Bull. 6, p. 38, pl. III, figs. 16–22.

Formation and locality.—Hamilton: Near Charlestown, Ind.
Cat. No. 1,231 M. I. T.

VASOCRINUS Lyon

1857. LYON, Geol. Survey Kentucky, III, p. 485.

VASOCRINUS SCULPTUS Lyon

1857. LYON, Geol. Survey Kentucky, III, p. 486, pl. IV, figs. 3*b–e*.

Formation and locality.—Onondaga (?): Louisville, Kentucky.
Cat. No. 36,011 (Rominger collection) U. S. N. M.

TAXOCRINUS Phillips

1843. PHILLIPS, Morris Cat. British Fossils, p. 90.

TAXOCRINUS LOBATUS (Hall)

1862. *Forbesiocrinus lobatus* HALL, 15th Rep't N. Y. State Cab. Nat. Hist., p. 124.

Formation and locality.—Hamilton: Thedford, Ontario. The type locality is in Ontario county, New York.
Cat. No. 26,379 U. S. N. M.

ARTHRACANTHA Williams

1883. H. S. WILLIAMS, Proc. Amer. Philos. Soc. (April), p. 84.

ARTHRACANTHA PUNCTOBRACHIATA Williams

(PLATE XVI, 4)

1883. WILLIAMS, Proc. Amer. Philos. Soc. (April), pp. 83, 86.

Among several fine specimens of *Arthracantha punctobrachiata* from the Hamilton of Thedford, Ontario, there is one on which the arms are exquisitely preserved. A figure of this specimen is introduced to show the character of these structures which have not, so far as known to the writer, been fully illustrated. The delicate pinnules and the rectangular form of the upper portion of the arms are especially to be noted. Other specimens show the spine bases and the delicate, ribbed spines which closely resemble those of the *Echinoidea*.

Cat. No. 26,380, 26,464–65 U. S. N. M.

Calyx Abnormalities in Camerate Crinoids

It is worthy of note that we have in this comparatively small collection a relatively large number of abnormal individuals. If the more unusual of these, such as *Megistocrinus sphæralis* n. sp. and *Dolatocrinus asterias* n. sp., had occurred as isolated specimens, they would doubtless be considered representatives of new genera, but they are associated with a series of forms having a peculiar surface or other feature by which their relationship can be determined. This being true for the more extreme forms, cases in which the abnormality is confined to a single plate may reasonably be accounted for in the same way. Mention of abnormal individuals has occasionally been made by other students of the *Crinoidea*. Bather[1] considers the type of *Mitrocrinus* as probably an abnormal individual. Miller and Gurley state, with reference to *Dolatocrinus ornatus* Meek, " In one ray of the typical specimen the second radial is abnormally wanting, while the other is larger than usual," etc. The occasional presence of such abnormal individuals does not destroy the force of the rule calling for a definite number of basals and radials in each species, but it is of interest as showing the amount of variation which may occur within the limits of a species, and is probably no more than could be found among recent organisms.

A table is appended showing the geological and geographical distribution of the crinoids studied in the preparation of this paper.

Table Showing the Distribution of Devonic Crinoids as Illustrated by the Collections of the United States National Museum and the Massachusetts Institute of Technology.

O, Onondaga, T, Traverse (Hamilton). H, Hamilton.	Alpena, Mich.	Petoskey, Mich.	Solon, Iowa.	Thedford, Ont.	Charlestown, Ind.	Falls of the Ohio.	Columbus and Dublin, Ohio.	Le Roy, N Y.
Arthracantha punctobrachiata				H				
Dolatocrinus amplus					H			
Dolatocrinus asterias	T							
Dolatocrinus cælatus ?					H		O?	
Dolatocrinus charlestownensis				H?	H			
Dolatocrinus costatus	T							
Dolatocrinus excavatus					H	H		
Dolatocrinus glyptus						H	O	
Dolatocrinus grandis						H ?		
Dolatocrinus greenei					H	H ?	O?	
Dolatocrinus hammelli					H			
Dolatocrinus indianensis ?					H	O ?		
Dolatocrinus lacus					H	H	O	
Dolatocrinus major						O ?	O	
Dolatocrinus ornatus						H ?	O	

[1] *A Treatise on Zoology*, ed. E. Ray Lankester.

O, Onondaga. T, Traverse (Hamilton). H, Hamilton.	Alpena, Mich.	Petoskey, Mich.	Solon, Iowa.	Thedford, Ont.	Charlestown, Ind.	Falls of the Ohio.	Columbus and Dublin, Ohio.	Le Roy, N. Y
Dolatocrinus pulchellus					H			
Dolatocrinus salebrosus					H			
Dolatocrinus sp						H ?		
Dolatocrinus triadactylus	T				H			
Dolatocrinus venustus					H			
Dolatocrinus wachsmuthi					H			
Gennæocrinus carinatus					H			
Gennæocrinus kentuckiensis						H		
Gilbertsocrinus indianensis					H			
Megistocrinus abnormis						H		
Megistocrinus concavus	T							
Megistocrinus depressus				? H	H	H	O	
Megistocrinus expansus	T				H	H		
Megistocrinus farnsworthi			X					
Megistocrinus latus		T						
Megistocrinus multidecoratus	T							
Megistocrinus nodosus ?	T							
Megistocrinus regularis	T							
Megistocrinus rugosus						H	O	
Megistocrinus sphæralis	T							
Megistocrinus spinosulus						H	O	
Megistocrinus tuberatus	T							
Stereocrinus barrisi	T							
Taxocrinus lobatus				H				
Tripleurocrinus levis								O
Tylocrinus novus	T							
Vasocrinus sculptus						O?		

EXPLANATION OF PLATES

(All figures are natural size unless otherwise stated.)

PLATE XV

Megistocrinus sphæralis n. sp..................p. 60

FIG. 1. Posterior view of a specimen with the base flattened by compression. The holotype.

1a. Lateral view of an uncompressed specimen showing normal outline.

1b. Fragment of base.

Megistocrinus tuberatus n. sp..................p. 57

FIG. 2. Basal view of an incomplete specimen, the holotype.

2a. Lateral view of specimen represented by fig. 2.

2b. Enlargement of portion of surface of specimen represented by fig. 2. × 2.

2c. Tegmen of a large individual which has been somewhat crushed. This figure is drawn with the dorsal side uppermost, as the plates are better shown with the specimen in that position.

See plate XVI, figs. 3, *3a*.

Megistocrinus abnormis (Lyon) . . . . p. 63

FIG. 3. Enlargement of a portion of the surface of a well-preserved specimen. × 2.

Megistocrinus regularis n. sp . . . . p. 59

FIG. 4. Lateral view of holotype.
4*a*. Basal view of specimen represented by fig. 4.

PLATE XVI

Dolatocrinus asterias n. sp . . . . p. 71

FIG. 1. Lateral view of holotype.
1*a*. Basal view of another specimen.

Tripleurocrinus levis n. gen. et sp . . . . p. 57

FIG. 2. View of type specimen embedded in limestone matrix.
2*a*. Top view of a stem joint. × 3.

Megistocrinus tuberatus n. sp . . . . p. 57

FIG. 3. Posterior view of a young individual.
3*a*. Basal view of same specimen.
See plate xv, figs. 2–2*c*.

Arthracantha punctobrachiata Williams . . . . p. 71

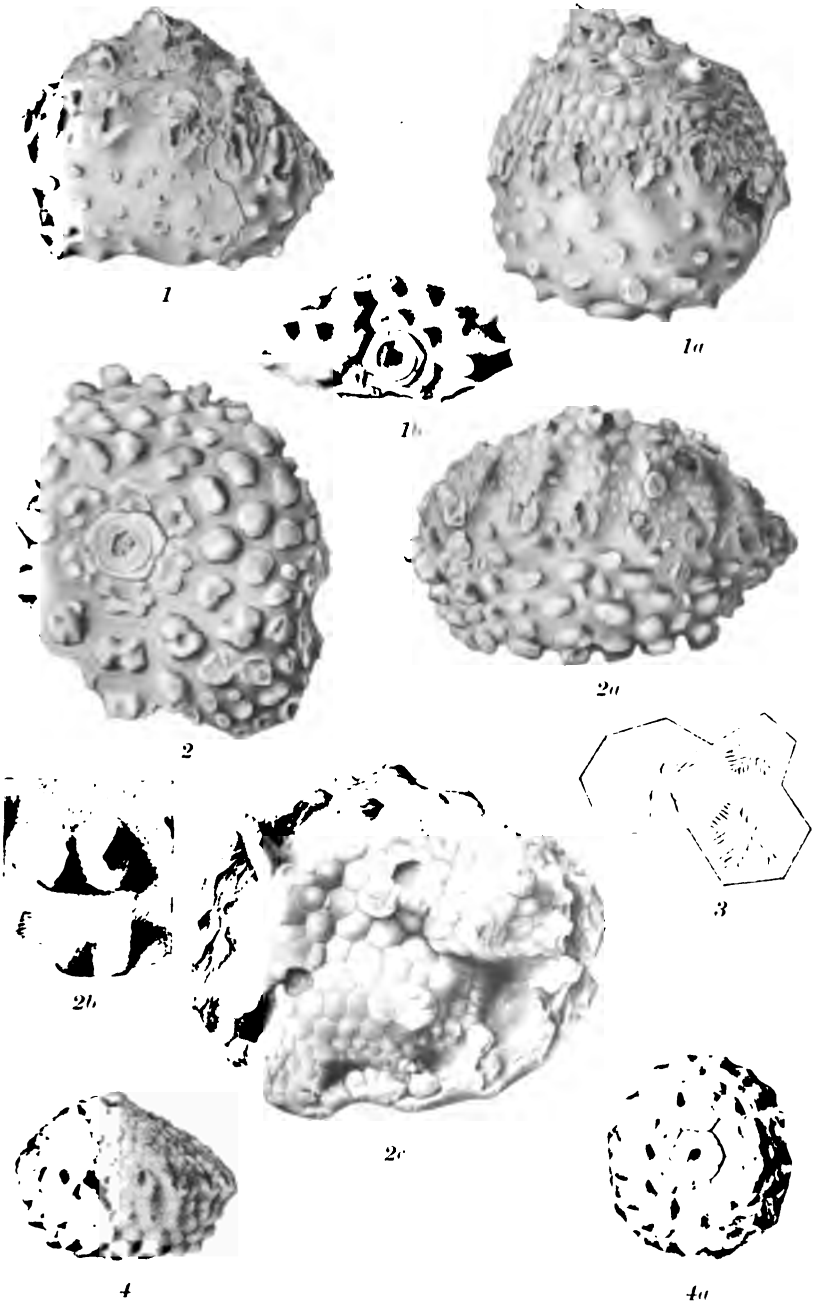
FIG. 4. Dorsal view of well-preserved individual embedded in shale.

Tylocrinus novus n. gen. et sp . . . . p. 66

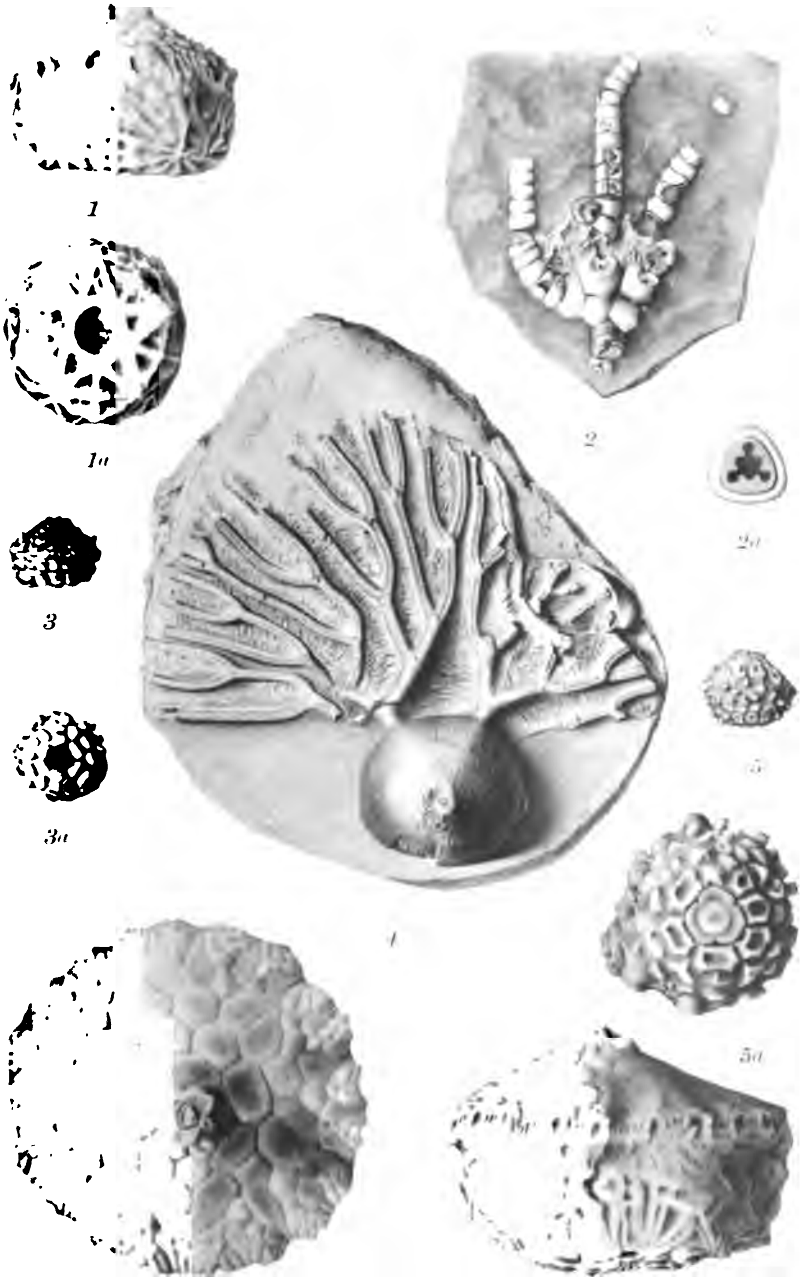
FIG. 5. Lateral view of holotype.
5*a*. Base of specimen represented by fig. 5. × 2.

Dolatocrinus costatus n. sp . . . . p. 70

FIG. 6. Tegmen of holotype.
6*a*. Lateral view of specimen represented by fig. 6.



MIDDLE DEVONIC CRINOIDS.



MIDDLE DEVONIC CRINOIDS.

KAVA DRINKING AS PRACTISED BY THE PAPUANS AND POLYNESIANS

By WALTER HOUGH

Among the customs peculiar to the inhabitants of the South Pacific islands, perhaps the most noted is that of the preparation and drinking of a narcotic beverage called *ava, kava,* or *yakona.* Much of its notoriety arises from the repulsive way in which it is sometimes made. Aside from this, it is characteristic of a certain oceanic area, and seems to be as strikingly limited to this area as is the stick-and-groove method of making fire. The custom, however, is not confined to one ethnic stock, many notices in literature showing that both Papuans and Polynesians practise it. In many of the islands the liquor is concocted by chewing the root of the *Macropiper methysticum,* or long pepper, ejecting the comminuted mass into a bowl, adding water, straining out the pulp, and drinking the fluid. In other localities it is made by simply grating the root and adding water.

The plant from which kava is made is a shrub of the natural order *Piperaceæ.* It is about six feet high, with stems ranging from an inch to an inch and a half in thickness; the leaves are cordate and from four to eight inches long. This family is the source of the pepper of commerce and contains several species that are of medicinal and commercial importance.

In making kava, the root and base of the stem are used. The roots usually weigh from two to four pounds, though sometimes as much as 22 pounds. Several varieties are distinguished by the natives; for instance, in Tahiti there is a yellow variety called *marea;* another, which becomes pink on exposure to the air, is called *avini-ute.*

Chewed when freshly gathered, the root first tastes sweet and aromatic, then bitter, acrid, and pungent. It provokes abundant secretion of saliva and in a few seconds occasions a sensation of burning on the tongue. The root contains about fifty percent of starch, a little pale-yellow essential oil, two percent of an acrid resin, and one percent of the neutral crystalline principle methysticin, called kavahin. To the latter principle we must attribute the toxic qualities of the kava preparation. The resin and the kavahin are insoluble in water, but are soluble in saliva and the gastric juices.

There are many accounts of kava drinking in the literature of Polynesia,—Cook, Ellis, Mariner, and Turner being among those who describe the practice in different islands. The author takes pleasure in acknowledging the use of notes on the Samoan custom, made in 1889 by Lieut. T. Dix Bolles, U. S. N.

In Samoa, the ava root is grated or chewed, then soaked, the woody pulp strained off, and the fluid drunk. The root is used either green or dry. The flavor of the liquid is at first like that of soapsuds, but immediately afterward a pleasant aromatic taste is imparted, faintly bitter, as in quinine. In Samoa, ava drinking is the accompaniment of all meetings of the men.

Formerly the root was chewed, but as that destroyed the teeth after a time, it is now generally grated. At councils the making is quite ceremonious and proceeds as follows: The host sends a young man for some fresh, dry ava, which is thrown into the semicircle of men and is examined, commented on, and finally tossed back to be cleaned of its bark. The host's daughter, the maid of the village, is called in and seats herself before the men; a hugh ava bowl is brought forward, together with several cocoanut shells full of water. The bowl and cup are washed; the fau, or whisk, to be used is wet and switched until dry; the maid's hands and wrists are bathed; and if the root is to be chewed, the mouths of the chewers are thoroughly rinsed. The quid is increased in size till the mouth will hold no more and is then deposited in the bowl, and so on until there is enough to make a drink for each of those present.

If, however, the root is to be grated, a tin grater is laid across the bowl, and the maid, sounding a musical rhythm, rubs until enough is procured. The remaining fragment of the root is thrown aside and a second maid or young woman pours into the bowl the proper allowance of water. The contents are then stirred by the maid and in a few moments the fau is bunched, dropped into the bowl, and by dexterous manipulation the pulp is caught, and the fau is wrung out and shaken by the assistants. This is repeated until the ava is free from pulp, when all clap their hands, saying, "The ava is ready; the bowl is prepared."

The drinking-bowl, usually a large half-cocoanut shell, is then presented, by an attendant, to the maid, who fills it. The master of ceremonies, familiar with those present, calls the name of the senior chief, who answers by a word, or by clapping his hands, that the attendant may know to whom to present the bowl. This is done by a low, long sweep of the arm, bending the body at the same time. The recipient drinks in silence, holding the cup in one or both hands, and, finishing at a single draught all that he intends to take, he pours the remainder on the stones and spins the cup before him. The drink is passed along by seniority till all have participated, when the large bowl is emptied upon the stones and the makers withdraw. Numerous quarrels originate from mistakes made in first presenting the cup to a person of inferior rank.

Nothing is said or done until all have been supplied, but a chief will often leave after his turn, and the council generally breaks up at the end of the drinking. If much ava is taken at one time the legs become helpless. It is believed to be a gentle tonic, preventing malarial fevers, and it is used freely.

The apparatus for kava preparation and drinking consist of few pieces, but they are among the finest manufactures of the islands.

The bowl is usually a circular, shallow, wooden vessel standing upon short legs. It is always of solid wood, for the Pacific islanders, like the Africans and other races of a certain degree of advancement, know nothing of joinery. They vary in size from 9 to 36 inches in diameter and are remarkable specimens of wood carving. In Samoa, the bowl is made of ifi lele, *Afzelia bijuga* GRAY, or Samoan chestnut; in Fiji, harder wood is used, and sometimes small bowls are made of iron-wood or of dense cocoanut palm. A pierced lug at the edge of the bowl is supplied with a cord of plaited coir for suspension. The bowl is never washed after use, but is allowed to dry, in order that the deposit left by the liquor may in time form a crust upon the surface, which renders the bowl highly valuable. On the interior of the bowl in the U. S. National Museum, presented to President Cleveland by Malietoa, one of the Samoan chiefs, there is a delicate sea-green polished patina that is very beautiful.

The cup from which kava is drunk is almost invariably made from cocoanut shell. The lower half of the shell is employed, being scraped and rubbed with stones under water into a thin, highly polished cup, forming a graceful and valuable drinking vessel. These are never wiped dry, that they may thus take on the enamel so valued in the bowl. The Samoan cocoanut, being of exceptional size, is much sought after in the islands for making cups. Usually they are pierced in the thicker portion at the point and supplied with a cord for hanging.

The strainer (fau in Samoan), is simply a long fringe of bark from the fau tree, *Hibiscus tiliaceus*. In Tonga, the strainer is made at the time of the kava ceremony, by crushing the green stalks of the

Cyperia cinctus, and drawing them repeatedly between two pieces of wood, securing the fiber filaments. The use of the fau is an art. It is dropped into the kava and by the most dexterous manipulations is made to enmesh the pulp, which is wrung dry and thrown aside.

The kava plant is cultivated in the Marquesas, where the infusion is used morning and evening like tea and coffee. In Tonga it is still in use, and also in Fiji, the home of the kava habit and where the liquor is called *yakona.*

Kava is at first stimulating, but the effect of an excess resembles that of opium, producing a drowsy drunkenness, lasting for two hours. The inebriate is usually peaceable, but sometimes is irritated by noises, which is attributed by natives to the use of kava grown in moist ground. The results of excess are skin disease, emaciation, and general decrepitude. The peculiar whiteness of the skin caused by kava drinking is said to be sought after in some islands as a sign that its possessor is wealthy enough to devote his time to its acquirement.

Kava was formerly drunk before warlike enterprises and religious festivals. It was a sign of peace, reconciliation, or of a rich present. The social element more frequently preponderated in the kava custom. In Samoa, ava circles or clubs were formed, and an objection of the natives to the introduction of Christianity on that island was that it would " break up our pleasant ava circles."

There is some misapprehension in regard to whether the liquid undergoes fermentation before it is consumed, but it is positively known that there can be no fermentation, for the liquor is drunk immediately after the addition of water to the macerated root. This beverage uniquely differs from all other drinks invented by man. Kava that is prepared by chewing is said to be more palatable, which is perhaps due to the conversion of the starch into a fermentable substance by the ptyalin of the saliva.

An account of kava would not be complete without a comparison with other beverages that have some points in common in their preparation. In Brazil, a drink called *chica* is made from cassava by the Indians. " The roots were sliced, boiled till they became soft, and set aside to cool. The young women then chewed them, after which they were returned into the vessel, which was filled with water, and once more boiled, being stirred the whole time. When this process had been continued sufficiently long, the unstrained contents were poured into earthen jars and allowed to ferment."[1]

[1] Kidder and Fletcher, *Brazil and the Brazilians,* Phila., 1857, p. 190.

TONGA NATIVES MAKING KAVA

In other parts of South America, maize was treated in the same manner in the brewing of beer. Kava differs widely, however, from this by not being fermented. The object of chewing in the case of the cassava beer seems to be in order to secure a suitable ferment, which is always present in the secretions of the mouth. Again, the conversion of starchy material by saliva is important to begin the process of fermentation. On the other hand, custom may have a strong influence, since they had an old superstition that "if it was made by men it would be good for nothing."[1]

Yeast had its origin in some such custom. The Hopi and Zuñi Indians prepare yeast by chewing corn meal. Among the former, at least, the chewing is entrusted to girls and healthy women, who seem to consume considerable time in the process. Among the Hopi the yeast appears to be for immediate use; the Zuñi add salt and lime to the liquid, checking fermentation, and keep it for some time without souring. In many parts of Mexico, also, yeast is prepared by chewing.[2]

The kava root was probably chewed as the most available way to disintegrate its fibers. The tin grater found an immediate adoption in Samoa. As an offset to the theory that the dialytic action of saliva on the starch may render the liquid more palatable, is the claim of the Samoans that the quid is dry when delivered from the mouth; but experiment shows that this is not the case, the root provoking the secretion of saliva. However, the continued presence of the material in the mouth might check the action of the salivary glands for a time. Another reason may be that since kava drinking was a semi-religious ceremony, or at first highly official in most islands, the custom may have been perpetuated as one giving greater efficacy to the potion.

Betel, which is extensively chewed by the Malays, Hindoos, Siamese, and other peoples, is perhaps the most complicated in its preparation of any narcotic. Four different ingredients enter into the quid, viz., leaves of the *Chavica betele,* chips of areca nut, gambier, and lime, resembling in the assembly and combination of these elements the compounds of more civilized society. That part of the betel compound which is of interest are the leaves of the piper, which are described as being bitter aromatic.[3]

---

[1] Kidder and Fletcher, op. cit., p. 191.

[2] The Oroches of the Amur prepare a drink by chewing up fish and ejecting it into a bowl, as the Polynesians make kava. The Fish Skin Tatars, *Jour. Asiatic Society of China,* 1890.

[3] F. Grabowsky, Das betelkauen bei dem malaiischen völkern, besonders aus Java und Borneo, *Internat. Archiv. f. Ethnog.,* 1888, v, p. 188.

There are some facts bearing on the spread of the kava custom among the islands which may enable us to determine the locality whence it took its rise.

It is of historic record when kava was introduced into Samoa from Fiji. According to the native account this was not very long ago. In the Papuan area the custom reaches its highest development, while to some of the Polynesian settlements it has never been carried, notably to Easter island, where, from the observations of Paymaster W. J. Thomson, U. S. N., it is not known. The reason for this is that the Easter islanders migrated before the custom found its way into their ancestral home (probably Rapaiti, 27° 35′ S. lat.; 144° 20′ W. long.; year, 1400).[1]

There is strong probability that the Papuans invented kava, because among this people its use was prevalent and the plant was systematically cultivated for the purpose of making the drink. The use of kava cannot be traced to New Zealand, though the Maori make use of a piper for tea and for toothache.

In New Guinea, at Mowat, the natives at the puberty feast drink the health of the young boys in a liquor called *komata,* made from a plant grown locally. Prof. A. C. Haddon thinks this is kava.[2]

d'Albertis says: " Maino brought me some roots which the natives chew for its narcotic and intoxicating properties."[3] This seems to point to the familiarity with kava among the Papuans of New Guinea.

A number of the arts and manufactures in the Pacific islands seem to be due to the progressive, woolly-haired peoples. Canoe and house building, stone-working, the use of the bow and armor, the making of pottery and bark cloth, some of these as evincing superiority, some as unique, may be credited to the Papuans.

The desire for narcotics and stimulants would seem to have grown from human necessity in response to a natural craving that must be supplied like any other desire, as thirst and hunger. The community of the instinct is shown by the almost universal use of stimulants and narcotics. Savors, flavors, and narcotics fall into the class of foods. As from the plainest and most simply prepared food there is an education to the appreciation of flavor and the refinements of preparation, so from the simplest of all beverages, water, there is a cultivation of the senses by the juice of the fruit, the nut, and the sap of plants, and the saccharomyces that float in the air soon put a vinous beverage into the hands of man. The origin of

[1] Peschel, *The Races of Men,* p. 349.

[2] *Jour. Anthrop. Inst.,* XIX, 1890, 4, p. 460.

[3] d'Albertis, II, 1880.

vinous beverages is a mere matter of the exposure of a fermentable juice to the air, which contains ferment spores usually in profusion. The use of such beverages is of great antiquity and their value for giving a novel sensation and a mental stimulus must have been early appreciated.

A line of argument might be followed to prove that the human mind has been spurred to greater intellectual activity since the advent of alcoholic beverages, but according to Peschel, conclusions of this sort are specious and have led Buckle astray into a whole series of attractive errors.

Some of the ruder tribes have no vinous drinks. The Patagonians are said to have no fermented drink, but they appreciate rum. They have a cooling drink made of the juice of barberries mixed with water, but it is drunk in its natural state. On the other hand, the Australians of New South Wales made mead, that was slightly intoxicating, from the honey of the wild bee.[1]

The Australians of Victoria "used compound liquors perhaps after a slight fermentation to some extent intoxicating—from various flowers, from honey, from gums, and from a kind of manna. The liquor was prepared in the large wooden bowls *tarnuk* [compare Samoan *tanoa*] which were to be seen at every encampment. In the flowers of a dwarf species of Banksia (*B. ornata*) there is a good deal of honey; and this was got out of the flowers by immersing them in water. The water thus sweetened was greedily swallowed by the natives. This drink was named beal by the natives of the west of Victoria and was much esteemed."[2]

The fact that nearly all aboriginal tribes are addicted to stimulants and narcotics in no less degree than are civilized races, is worthy of careful consideration. The relation of drinks and drugs to ceremonies and ordeals has already been studied by the late Captain J. G. Bourke, U. S. A., with valuable results to science.

The entire question of drinking is a very broad and interesting study, extending in its range from the first use of water to the last mighty aqueduct that brings a river to millions of lips, and including likewise the thousand and one beverages as well as the appliances for distributing and serving them. The subject has also its intellectual surroundings in folklore and custom.

The corruption of aborigines through intoxicants introduced by traders is not as original as may seem at first sight, for nearly every tribe already had similar agents differing only in degree of strength,

[1] T. A. Braim, *Hist. of New South Wales*, 1846, vol. II, p. 248.

[2] J. B. Smyth, *The Aborigines of Victoria*, vol. I, p. 201.

traders supplying only an existing need with more effective means of gratification. It is scarcely necessary, in support of the first assertion, to mention the different practices of rude peoples with respect to intoxication, nor to point out how the vegetal world has been ransacked to furnish the stimuli. Kava drinking is a good example of this.

RECENT RESULTS ON THE MORPHOLOGY AND DEVELOPMENT OF CORAL POLYPS[1]

By J. E. DUERDEN

INTRODUCTION

Students of the cœlenterates have long been aware of the insufficiency of our knowledge of the morphology and development of the animals which produce the calcareous skeletons popularly known as corals. The skeletons themselves are thoroughly known, even to their microscopic detail, but of the polyps which formed them, and which covered them while alive, we know comparatively little.

It is not difficult to assign a reason for this. It has been the privilege of few naturalists to make a prolonged stay within tropical regions, which are the home of by far the greater number of living corals, especially of the larger massive forms which make up coral reefs; yet it is only by direct study on the spot that many of their characteristics can be determined, their development followed, or suitable material procured for later anatomical and histological investigation. Beyond the observation of their living external characters, the polyps must be narcotized and preserved under proper conditions, and slow decalcification carried out to remove the hard calcareous skeleton so as to obtain the soft tissues in their natural relationships for microscopic examination.

A residence for the last few years within the West Indies, in the region of coral reefs, has afforded me the opportunity of investigating the morphology and development of a certain number of coral polyps. In all about thirty species have been fully examined, both in their living condition and anatomically, and the development of several forms has been followed for longer or shorter periods. Only the principal results can be here outlined.[2]

[1] A lecture delivered at the Marine Biological Laboratory, Woods Hole, Massachusetts.

[2] Fuller details will be found in volume VII, 7th memoir, of the *Memoirs of the National Academy of Sciences,* and in a series of four shorter papers in the *Annals and Magazine of Natural History* from May, 1902, to February, 1903.

BORING ALGÆ

One incidental result of the decalcification of so many freshly preserved corals has been the revelation that the madreporarian skeleton is almost universally infested with minute, filamentous, boring algæ. Every fragment decalcified, with the exception of pieces from near the growing apex of branching colonies, has yielded material of a fluffy texture within the spaces previously occupied by the corallum. Particles representing the organic matrix of the skeleton are mingled in the fluffy mass, but by far the greater part consists of microscopic algal filaments, which are usually green in color but occasionally red. Further, on cleaning away by maceration the animal tissues of freshly collected corals, the skeleton is frequently found to be green or pink in color, either as a whole or in part; and closer examination proves this to be due to the presence upon the surface and within the calcareous substance itself of closely ramifying filaments of green or red algæ. Not only the West Indian corals have been found thus infested with boring plants, but fragments from many Pacific species and even fossil corals of Paleozoic times have disclosed the same.

Of the green algæ two forms only have been found: one in which the filaments are provided with transverse walls, and another with continuous tubes, belonging to the group of the Siphoneæ. Both are extremely variable as regards the size, form, and extent of branching of the filaments, and are often closely intermingled in the same fragment of coral. Only one species of red alga has been found, and this is represented by simple, closely intermingled filaments. The non-septate green species frequently bears club-shaped or spheroidal enlargements which contain spores, but no reproductive bodies have been found on the others. No fungi have been observed, so that probably the saproleginous *Achlya penetrans* of other writers is really an alga; old preserved material does not show the chlorophyll granules, although so obvious in fresh coralla.

Much significance has been attached in recent years to the presence of boring algæ and fungi in calcareous organisms other than corals, especially in shells of mollusks, both living and dead. Moreover, the corroding activity of these Thallophytes has been shown to play a very important role in the ultimate disintegration of dead calcareous matter, reducing the carbonate of lime once more to the soluble state. In this respect they are to be compared with the putrefactive bacteria in their action on dead organic matter generally. The physical and chemical processes involved in the entry of delicate plant filaments within the dense calcareous structures are not fully understood, but the possibility of the ultimate destruction of an infested skeleton by this means is beyond doubt.

While the corroding algal filaments are thus general within the living superficial areas of the corallum, they are even more prevalent in the dead older parts, being particularly plentiful in so-called "rotten coral." Here they are associated with other superficial or boring organisms, such as boring mollusks, echiurids, sponges, and other agents of coral disintegration. The algæ continue their corroding activity even on the separate particles of dead coral after fragmentation, for fresh coral sand when dissolved in acids yields filaments in a living condition.

The universal occurrence of coral-boring algæ, possibly resulting in the ultimate disintegration and corrosion of the infested blocks, has manifestly some bearing upon the much discussed subject of the origin of the various forms of coral reefs, with which are associated the names of Darwin, Dana, Murray, Agassiz, and others. To account for the formation of many of the barrier reefs and atolls of coral seas it is necessary to assume a constant disintegration or removal of the older coral growth as the outer living edge of the reef continues its progress outward. In this destructive work the ever-present corroding activity of boring algæ is undoubtedly to be accorded an importance along with the more obvious coral-boring organisms, supplemented by actual solution in sea-water.

COLORATION

Almost all writers on coral reefs have emphasized the brightness and variety of hues exhibited by the living polyps. Different tints of brown, green, yellow, and blue are intermingled in never-ending variety, and even the same species may present much diversity in passing from one locality to another. Yet the color of living corals is in part incidental, that is, independent of the true nature of the polyps. Over West Indian coral areas the different shades of yellow or brown predominate, and these are found to be due mainly to the presence of zooxanthellæ or yellow algal cells within the endoderm of the polypal tissues. These are symbiotic unicellular plants, bearing yellow chromoplasts, and as a rule are distributed throughout the inner layer of the polypal wall, giving a light-yellow tinge to the colony where sparse, and a dark-brown effect where crowded. The two closely allied genera, *Astrangia* and *Phyllangia,* are the only forms in which zooxanthellæ have not been found, and the living tissues of these are characterized by an appearance of extreme delicacy and transparency, well exemplified by the *Astrangia danæ* of the eastern coast of the United States. Where colonies of other species are found growing in the absence of much light, the polyps are colorless, and zooxanthellæ are sparse or wanting.

Other more brilliant colors of corals are produced in various ways. Most are ectodermal, due either to fine, granular pigment matter within the layer, or to some superficial deposit. Distinct pigment cells may also occur, either in one or both layers of the body wall; at other times large pigment granules are more or less uniformly distributed, rendering the tissues dense and opaque. Experiments are much needed to determine the part which the zooxanthellæ and other coloring agents play in the physiology of the polyps, and also as to their adaptive significance.

THE POLYP WALLS

The external walls of coral polyps, represented by the column and disk, are constituted of the usual three cœlenterate layers: an outer ectoderm, an inner endoderm, and a middle mesoglœa. The polypal walls are usually thin and delicate, when compared with the majority of polyps of the closely allied actinians, the difference being dependent on the degree of development of the middle layer or mesoglœa. The ectodermal and endodermal epithelia are found to vary comparatively little in height throughout the Anthozoa, so that any diversity in thickness of the polypal wall as a whole is determined by that of the mesoglœa. Support for the polyp is afforded by the skeleton in corals, hence there is no necessity for any special development of the middle layer, such as gives a certain degree of firmness to many actinians. In general the mesoglœa of coral polyps is a mere separating lamella; where, as in the mesenteries, it may attain considerable thickness, it is usually a clear homogeneous substance, though in some species connective tissue cells occur sparsely.

Both the ectoderm and endoderm are richly provided with unicellular gland cells, which give out copious supplies of mucus when the polyps are irritated. An ectodermal muscle layer, the fibers either longitudinally or radially arranged, has been found only on the tentacles and disk, while the endodermal circular musculature of the column is usually only feebly developed. In some of the larger species the latter constitutes a diffuse endodermal sphincter, but never becomes so concentrated as to form a circumscribed or mesoglœal sphincter such as occurs in many actinians (bunodactids, sagartids).

On complete retraction of the polyp the upper part of the column generally folds over the tentacles and greater part of the disk, due to the action of the circular musculature; but in some few cases the disk and tentacles remain wholly exposed, even when the greater part of the polyps is withdrawn within the skeleton. The term edge-zone, or *Randplatte,* so frequently employed in coral literature, refers to the lower, pericalicular portion of the column wall, the thecal wall having divided the polyp vertically into intra-calicular and extra-calicular parts, each containing portions of the mesenteries and gastrocœlomic cavity.

Coral polyps in general remain retracted or partly retracted during the day, and expand to their full degree only at night time or when placed in the shade (negatively phototropic).

TENTACLES

The tentacles of coral polyps are arranged mostly in alternating, hexameral cycles, the inner larger than the outer, as in the majority of hexactinians. Usually the cycles are close together around the margin of the disk, but in *Fungia, Siderastrea, Agaricia,* and one or two other genera the individual tentacles are widely separated and spread over nearly the whole of the disk. One tentacle arises from each mesenterial chamber, and thus corresponds in position with the septa below; in *Agaricia* and some other genera the outermost cycle of exotentacles is wanting, and no instance of the stichodactylinous arrangement (*i. e.,* in radial rows, several tentacles from each chamber) has been found. Perhaps the majority bear a knob of stinging cells at the apex, and smaller batteries along the stem. All are simple in form, except in *Siderastrea,* where the entocœlic members are bifurcated about midway along their length. Frequently the tentacles undergo invagination within the polypal cavity, even when the polyps are fully expanded; and occasionally on fullest expansion they temporarily disappear as outgrowths, becoming part of the discal expansion.

In fissiparous genera the hexameral plan of the tentacles is altogether lost, and in extreme cases (*Mæandrina, Pectinia*) the organs are merely dicyclic, having an inner entocœlic and an outer exocœlic series.

Frequently in adult gemmiferous polyps the last entocœlic and the exocœlic cycles are hexamerously incomplete, that is, growth ceases before the completion of the last entocœlic cycle commenced; otherwise the cycles follow the normal hexameral plan with the formula, 6, 6, 12, 24, etc.

STOMODÆUM OR ŒSOPHAGUS

The stomodæum of all coral polyps fully investigated is found to be without siphonoglyphs or gonidal grooves, a structure characteristic of most actinians and alcyonarian polyps. Though the œsophagus is oval or slit-like in section, the extremities show no histological differences from the sides. In many species the stomodæal walls all round are deeply ridged and grooved, in a manner unlike anything which occurs in ordinary actinians; the ridges correspond with the insertion of the mesenteries, and where strongly developed are histologically different from the grooves.

MESENTERIES AND MESENTERIAL FILAMENTS

The mesenteries, like the tentacles, conform to the hexactinian cyclic plan—6, 6, 12, 24, etc., either throughout or during only the early stages of growth. Two great groups of corals, however, are recognizable, according as the asexual growth of the colonies takes place by budding or by fission. In the former the bud polyps are, to all intents and purposes, new polyps, having the mesenteries throughout arranged in hexameral alternating cycles, with two pairs of directives, exactly as in polyps reared directly from larvæ. Though in the adult polyp the last cycle of mesenteries commenced may not reach the number of pairs necessary to complete the hexactinian plan, yet so far as the additions are made they follow the normal sequence. Where fissiparity is established, however, the cyclic arrangement is irregular, the early hexamerism is altogether lost, and no new pairs of directives arise. Whenever, as is the case in some polyps, directives and cyclic hexamerism are wanting, it may with good reason be assumed that the polyps are products of fission, not of gemmation (p. 102).

The mesenteries are restricted to the upper half or two-thirds of the polyp, being resorbed in the lower region as the polyp grows upward. Histologically the retractor and oblique muscles are always feebly developed, parieto-basilar muscles seem to be absent, and no evidence of mesenterial stomata is forthcoming.

Mesenterial filaments occur on nearly all the mesenteries, both complete and incomplete, though sometimes they are merely incipient on the youngest cycles. In all the species examined the filaments are simple, not trilobed as in most actinians. In the latter group two lateral lobes are developed, in addition to the median lobe, and these bear the ciliated bands, which are specially concerned in the circulation phenomena of the polyp. In both groups, however, the histology of the terminal lobe is the same, but in certain corals it undergoes a remarkable modification, constituting what must be regarded as a special glandular organ. For a limited part of its course the filament becomes greatly enlarged, and all the cells, with the exception of the supporting cells, are charged with a finely granular secretion, yellowish in color. Sometimes the glandular differentiation may extend so as to include part of the mesenterial epithelium adjacent to the filament.

In the lower part of their course the mesenteries and filaments may become greatly convoluted, and, when much disturbed, the living polyps have the peculiar power of extruding the filament along with the part of the mesentery to which it is affixed; they can, however, be again indrawn as the polyps recover. Sometimes the filaments are forced out in such quantities as to give a ragged appearance to the surface of a colony. The extrusions take place through the oral aperture or any part of the column wall or disk; in the latter case minute pores are made in the polypal wall, but after the mesenteries and filaments are indrawn the punctures are healed, and the wall then affords no indication of their former presence.

The phenomenon of extrusion of the filaments is in some ways comparable with the emission of acontia through cinclidal pores which takes place in certain anemones (sagartids); but here the acontia are sent out as threads distinct from the mesenteries, and the cinclides are permanent apertures, whereas, in corals, a part of the mesentery accompanies the filament, and the openings are temporary and may be produced at any part of the polypal wall.

SKELETOGENIC TISSUES

All the researches on the development of corals, as well as on their adult relationships, serve to demonstrate that the entire coral skeleton is an ectoplastic product of the basal disk, that is, it is formed altogether external to the polyp itself. On decalcification the polyps remain as perfect organisms, their walls intact throughout, intricate infoldings of the lower part representing the spaces formerly occupied by the skeleton. All the radial (costæ, septa) and tangential (theca) elements of the corallites correspond with so many infoldings of the basal part of the polyp, which have been produced *pari passu* with the deposition of calcareous matter.

Considering the colony as a whole, the polyps themselves are altogether superficial, however thick may be the coral stock. The soft tissues extend only a few millimeters within the skeletal mass, or in large polyps a centimeter or so, being cut off from the skeleton below by transverse dissepiments.

The three cœlenterate layers lining the skeleton, and by which the skeleton is produced, have each undergone certain modifications compared with their character in the column and oral disk. In most instances the endoderm becomes greatly thickened and vacuolated in passing from the upper to the lower regions of the polyp, so that proximally it greatly reduces the polypal cavity, the mesenteries being also wanting in this region.

The mesoglœa, as elsewhere throughout the polyp, is a thin homogeneous lamella, but in certain areas it is produced into conical or wedge-shaped processes, striated toward their extremity, and coming into direct contact with the skeleton. These have recently been shown by Bourne to take their origin from modified ectodermal cells, which he terms *desmocytes*, and the desmoidal processes are considered to serve as a means of attachment of the polyp to the corallum. They are best developed along the line of union of the mesenteries with the skeletotrophic tissues, and where skeletal formation is not in progress.

The basal ectoderm is the true skeletogenic epithelium, and varies greatly in character according as it overlies a region of active skeletal formation, or an older region where growth is stationary. At the apex of branches, and the edge of growing septa, the layer is broad and highly protoplasmic, while the individual cells, termed calicoblasts, have either distinct walls or are fused into a common mass or cœnocyte. In the non-growing areas the skeletogenic layer is usually extremely narrow, being scarcely recognizable in sections of decalcified material. The calicoblasts are usually in an active state in the deepest or most proximal part of the polyp, as it is here that the calcareous dissepiments are continually being formed as the polyp grows upward.

In very carefully decalcified material, from rapidly growing regions, a homogeneous skeletal matrix or ground substance remains in the space formerly occupied by the skeleton. It resembles the mesoglœa in its behavior toward reagents, though with the form and detailed microscopic appearance of the skeletal fibers. It is thus manifest that the calcareous skeleton, though formed externally to the polyp, is laid down within a colloidal matrix produced by the skeletogenic tissues. After decalcification of the older parts of the skeleton there is little evidence of this organic matrix except immediately next the calicoblast layer. Here the matrix is usually represented by a thin homogeneous layer, which has been regarded as a skeletal membrane, coming between the actual polypal tissues and the corallum.

The *synapticula,* which are solid calcareous bars, uniting adjacent septa across an interseptal loculus, are found actually to perforate the skeletotrophic tissues lining the two walls of the loculus, and also any mesentery which may be included within the loculus. Recently they have been described as originating from independent continuous upgrowths of the basal disk, but the anatomy of the polyps gives no support for this conception.

ASEXUAL REPRODUCTION

Vegetative or asexual increase assumes a great importance in the growth of corals, resulting in the production of colonies or stocks, often of large size and complexity of form. Yet, however diverse in form the colonies may become, their origin can be reduced to two sharply-defined processes, namely, *budding* and *fission.* Many varieties of both types of increase have been studied, and reveal that the resulting colonies are characterized by morphological differences of much significance.

Budding or gemmation may take place from almost any part of the polypal wall, and in every case the buds are found to reproduce all the characteristics of the larval polyp. The mesenteries, tentacles, and septa display a cyclic hexamerism, and two pairs of directives occur. Also in the course of their development the organs in buds pass through practically the same stages as in polyps reared directly from larvæ. Hence it follows that coral polyps arising by gemmation are to be regarded as new and distinct individuals, just as much as polyps originating by sexual means.

It is otherwise where a colony increases by fissiparity. The process has been traced in *Manicina areolata* (Linn.) and *Favia fragum* (Esper) from the larva, through the simple polyp, until fission is fully established, leading to a complex polyp. The diagrammatic figures 14 and 15, with their explanation, fully illustrate the stages in *Manicina.* While yet simple, the polyp presents all the characters of an ordinary cyclic hexameral species, including the presence of two pairs of directives. The first act of fission divides the stomodæum into practically equal parts, each with half the original number of complete mesenteries attached to it, and including, of course, only one pair of directives. The number of mesenteries increases with the growth of the fission polyp, and the hitherto incomplete pairs become complete by reaching as far as the stomodæum. It is found, however, that in the later stages the mesenterial increase rarely proceeds equally all round the polyp. Fission of one or both of the two stomodæa may now take place, perhaps with a variable number of mesenteries attached to each moiety; the same process is continued, the incomplete mesenteries in turn become complete, and new pairs are developed, but additional directives are never formed. In every case the fission plane is within two entocœles.

Examination of parts of the polypal system of mature fissiparous corals, such as species of *Isophyllia, Mæandrina,* and *Favia,* fully confirms the results from the early fission stages of other forms. The mesenteries, septa, and tentacles are not disposed in ordinary cycles, no hexamerism or other regular arrangement is determinable, and directive mesenteries are absent. The important conclusion is thus reached that a fissiparous coral, however large, morphologically represents but one complex individual polyp, having many oral apertures and the mesenteries in separate stomodæal systems; on the other hand, a gemmiferous colony is constituted of numerous distinct individuals, practically all alike.

A third, somewhat intermediate form of non-sexual increase sometimes occurs. On most gemmiferous colonies certain polyps are found which are much larger than the others, growing to as much as double the usual size, and among them are various stages leading to division into two daughter polyps. They suggest that the polyps are undergoing ordinary fission, for which reason it has been assumed that both gemmation and fission may occur on one and the same colony. An anatomical examination of many such enlarged polyps reveals, however, that they are not instances of true fission as above established. The resulting moieties are found to be really new individual polyps, having two pairs of directives and cyclic hexamerism, just as in polyps arising in the ordinary way as buds or from larvæ. This is clearly shown in figure 16, representing a section through an enlarged polyp of *Cladocora arbuscula* in process of fission. In the living condition the whole polyp was surrounded by a single column wall, and provided with a single tentacular system and a bioral disk. Manifestly fission is taking place across the median plane, and, when completed, each half will represent a distinct hexamerous *Cladocora* polyp, comparable with others arising as ordinary buds.

The growth of these enlarged polyps has been followed step by step on several different species of *Madrepora, Porites, Solenastræa,* and *Oculina.* It is found that new pairs of mesenteries are added to an ordinary polyp without increasing the number of cycles, and that in the end, when a double series of mesenteries has appeared, including two pairs of directives, the stomodæum divides, and half the mesenteries are apportioned to each. The process has been termed *fissiparous gemmation.* Instances of it occur on most gemmiferous colonies, but hitherto its significance, as contrasted with ordinary fission and gemmation, has not been understood.

SEXUAL REPRODUCTION

Coral polyps in general seem to be hermaphrodite, both ova and spermaria occurring on the same or separate mesenteries. Whenever

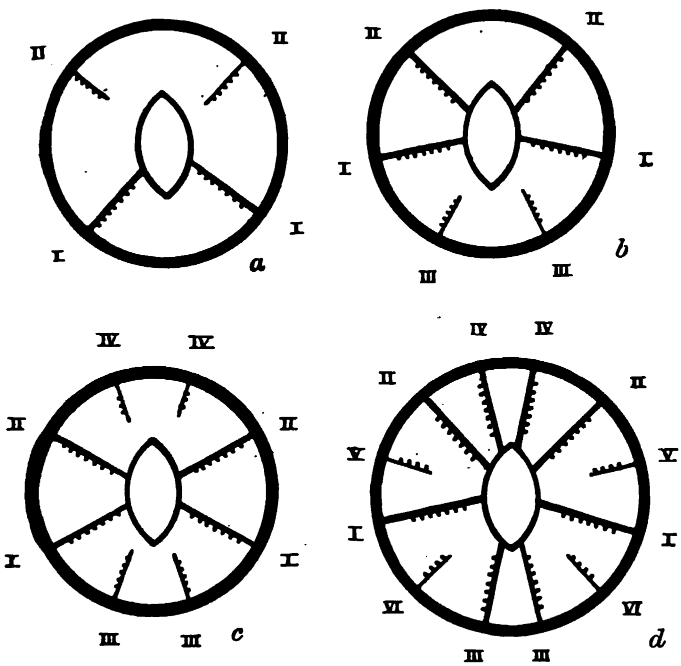


FIG. 10.—Four diagrammatic figures showing the order of appearance of the six primary pairs of mesenteries. In *a* only two pairs of mesenteries are present, of which one pair (I) is united with the stomodæum, while the other (II) is free; in *b* the second pair of mesenteries has become complete, and a third pair (III) has appeared on the ventral border; in *c* another pair (IV) is found within the dorsal chamber; in *d* the first four pairs of mesenteries to arise have all become complete, and the fifth and sixth pairs (V, VI) have appeared, but remain incomplete for a long period, the secondary mesenteries appearing in the meantime (cf. figure 11). The actual stages given are taken from *Manicina areolata,* but a like sequence is presented by other species whose development has been followed.

reproductive cells of only one kind are present, these are found to be ova, though one or two observers have described spermaria only. However when the ova are developed in greatest number they are found to be accompanied by spermaria, so there is good reason to suppose that, as a rule, coral polyps are protogynous.

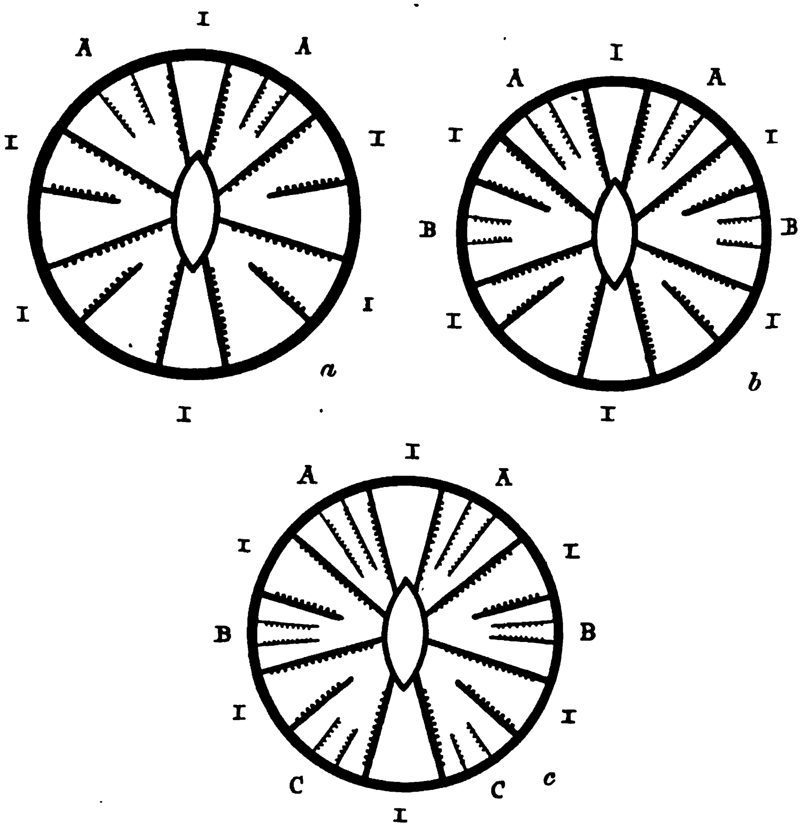


FIG. 11.—Three diagrammatic figures illustrating the manner of appearance of the six pairs of mesenteries (A–C) constituting the second cycle. The mesenteries arise in unilateral pairs within corresponding exocœlic chambers on each side of the polyp. At first (*a*) a pair appears within the dorso-lateral exocœle on each side; shortly after (*b*) a similar pair arises within each middle exocœle; then (*c*) a pair within each ventro-lateral exocœle. For a long time the pairs retain a difference in size, corresponding with their order of appearance. The sequence is that followed in the development of larval polyps of *Siderastrea radians.*

In some few cases the extrusion of free ova and spermaria has been observed, but it may be questioned whether such instances are not fortuitous in character, for in the same species free swimming larvæ have been found within the polypal cavity. Hence there is little doubt that all corals are viviparous. It is somewhat remarkable that though ripe polyps, and others charged with larvæ, have been abundantly met, none of the intermediate developmental stages be-

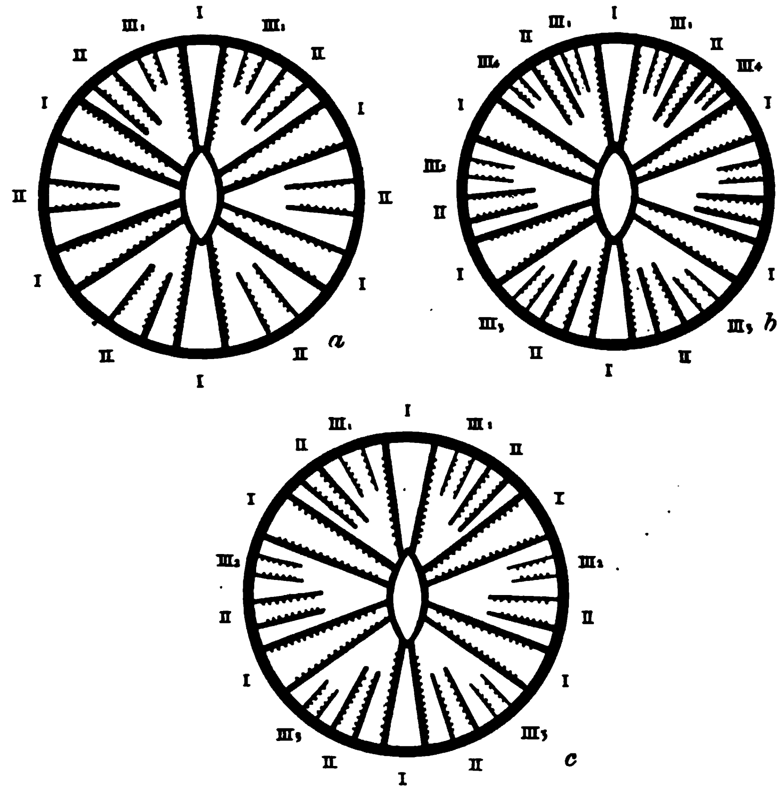


FIG. 12.—Three stages in the development of the twelve pairs of third-cycle mesenteries. All the six pairs of primary mesenteries are now complete, and the second-cycle pairs are all equal, but free from the stomodæum. In *a* a pair of third-cycle mesenteries (III) has appeared on each side, within the exocœle next the dorsal directives; in *b* a corresponding pair occurs within the dorsal of the two exocœles of all the six systems, the order being from the dorsal to the ventral aspect; in *c* another series of six pairs is commencing, situated within the ventral of the two exocœles in each system. Here, again, the growth in the dorsal region is in advance of that in the ventral.

tween the egg and larva has been encountered within the polyp. The only account of the segmentation and formation of the germ layers available is that given by H. V. Wilson[1] for *Manicina areolata.*

[1] *Journal of Morphology*, vol. II, 1889.

Larvæ are extruded from the parent polyp, either singly or in batches, at somewhat different stages of development in different species. They are only two or three millimeters in length and are generally pear-shaped, the swollen extremity being either the oral or aboral pole. The larvæ are able to swim around, with the aboral pole foremost, either directly or shortly after they are free, the entire surface being uniformly ciliated. The ectoderm of the oral pole is generally charged with numbers of zooxanthellæ or yellow cells

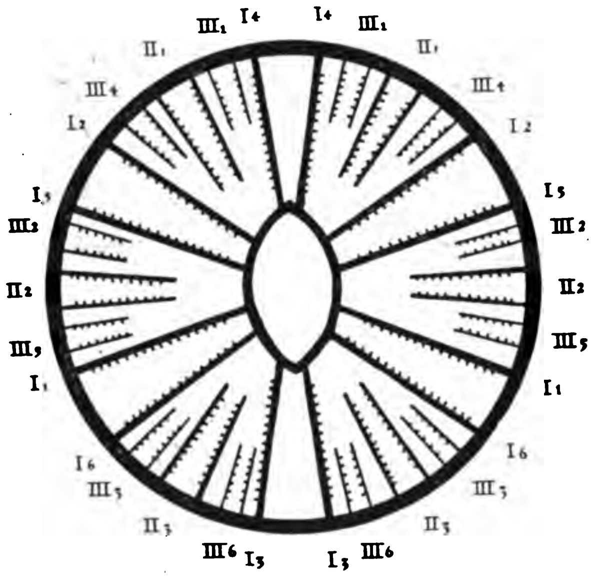


FIG. 13.—Diagram showing the order of appearance of all the mesenteries in a polyp having three cycles. The Roman numerals represent the cycle to which the mesenteries belong, and the smaller Arabic numerals indicate the order in which the mesentery appeared within its cycle. The regularity here indicated is constant for the primary and secondary cycles, but departures may be encountered in the third cycle. The sequence represented is that followed by *Siderastrea radians, Astrangia solitaria, Phyllangia americana,* and *Favia fragum.*

which give a dark appearance to this extremity. The occurrence of such symbiotic algæ in the ectoderm cells of the larva is somewhat remarkable, considering that they are never found within this layer in the adult polyp. Moreover, as the larva settles, and assumes the polypal form, the algæ slowly disappear, remaining in the adult only within the endodermal layer.

In nearly all coral larvæ yet investigated a special development of nervous elements takes place in the ectoderm at the aboral extremity, and the layer generally undergoes certain other modifications. The whole structure suggests a larval sense-organ for the forward, aboral pole, a similar organ occurring in the free-swimming larvæ of most of the higher groups of animals. It altogether disappears when fixation takes place by this extremity, thus having only a larval significance.

On first extrusion the oral aperture of the larva is usually indeterminate, the stomodæum is non-functional, and the interior is more or less filled with highly vacuolated tissue. Soon after liberation, however, the middle part of the latter becomes disorganized, and extrusions of yolk, zooxanthellæ, and cell débris take place through

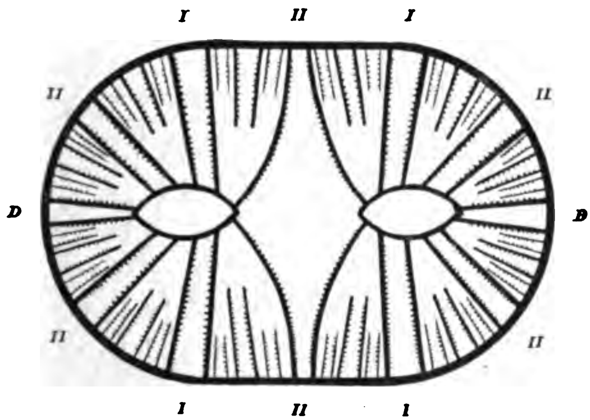


FIG. 14.—Diagrammatic figure illustrating the first stage of fission in a polyp of *Manicina*. Compared with the stage represented in figure 13, the six pairs of secondary mesenteries (II) have become complete, and an additional cycle of twenty-four pairs, constituting the fourth order or third cycle, has appeared. The stomodæum has become divided into halves, each having six pairs of mesenteries attached to it. The plane of division is entocœlic, and the pairs of directives (D) are situated at the opposite extremities.

the oral aperture, the larva becoming at the same time thinner walled and more transparent. The larvæ usually settle within from one to three days after being set free, but the free-swimming stage may continue for several weeks, though little or no development takes place in the meantime.

POST LARVAL DEVELOPMENT

Either before or shortly after extrusion of the larva, the six primary pairs of mesenteries (protocnemes), constituting the first cycle, make their appearance. The organs arise in bilateral pairs, in a regular and well-defined order, which is uniform for all the species yet studied. The first two or three pairs arise around the oral extremity of the larva, while the others first appear at varying distances down the wall. The protocnemic sequence is represented by the Roman numerals in figure 10, and agrees with that established for the greater number of actinians. The first four pairs very early unite with the stomodæum, but the fifth and sixth pairs remain free or incomplete for a lengthened period, suggesting a different phylogenetic significance from the others.

The six pairs of second cycle mesenteries (metacnemes) arise after fixation, but in a manner altogether different from that followed by the first cycle. They appear on the polypal wall in unilateral pairs or couples within the six primary exocœles, and in a succession which

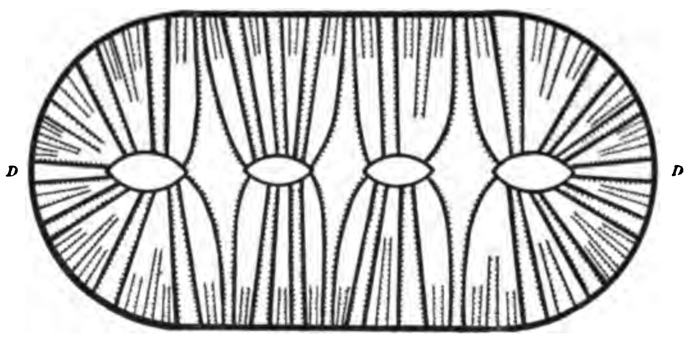


FIG. 15.—Arrangement of the mesenteries in a polyp of *Manicina* with four oral apertures and four stomodæal systems. The cyclic hexameral plan is departed from, and only the two primary pairs of directives (D) are present.

is from the dorsal to the ventral side of the polyp, not the whole cycle at a time. For a long time, as shown in figure 11, the six pairs present a difference in size, corresponding with their dorsoventral or antero-posterior order of appearance.

The twelve pairs of third-cycle mesenteries are found to develop in a succession which is altogether unexpected. They follow the same dorso-ventral order as the second cycle pairs, but in two series. A primary series of six pairs—one pair within each sextant—appears within the exocœle on the dorsal aspect of each of the second cycle mesenteries, one pair following upon another, and then another series of six pairs arises on the ventral aspect of the second cycle mesenteries in the same order (figure 12). In the later stages of growth the regularity of the mesenterial succession is not always maintained; one region may be somewhat in advance of, or may lag behind, its normal development.

The sequence thus outlined in the briefest manner is sufficient to show that the development of the mesenteries in coral polyps is bilateral, and takes place in stages from one extremity to the other. The radial symmetry, characteristic of the adult polyp, is thus derived from primitively bilateral organs, which appear in an antero-posterior succession. Moreover, each cycle represents a separate period of growth, as compared with the successive growth in one direction of ordinary segmented animals.

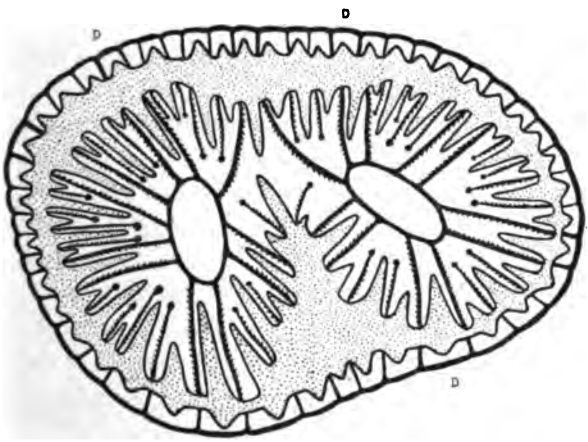


FIG 16.—Transverse section through the stomodæal region of a bioral polyp of *Cladocora arbuscula*, showing the character and arrangement of the mesenteries in a late stage of fissiparous gemmation. The plane of separation is entocœlic, and each polyp exhibits nearly perfect cyclic hexamerism, with two pairs of directives (D). The figure should be compared with figures 14 and 15 representing true fission in corals.

The first two cycles of tentacles (prototentacles) generally arise a cycle at a time, either simultaneously or one following the other. The later tentacles are developed in an order in correlation with that of the mesenteries, sometimes entocœlic and exocœlic members appearing together. In the process of growth the exocœlic members are always relegated to the outermost cycles, in a manner first established by Lacaze-Duthiers for actinians; only the entocœlic tentacles are of any ordinal value. *Siderastrea radians* (Pallas) is exceptional in that the exocœlic tentacles appear in advance of the entocœlic.

The skeleton never appears until after fixation of the larva. It makes its first appearance in the form of minute plates or granules, as an ectoplastic product of the ectodermal cells (calicoblasts) of the base. A flat, circular, basal plate is formed by the union of these, and may be produced upward at the edge as the epitheca, while from its inner or polypal surface the septa begin to appear as vertical upgrowths formed within invaginations of the basal disk of the polyp. The skeletal cup first formed is known as the prototheca.

Like the tentacles, the first two cycles of septa (protosepta) may appear simultaneously, or the cycle of six entosepta may arise in advance of the cycle of six exosepta. The order of appearance of the later cycles is not yet thoroughly understood, the relative sizes in the mature corallum by no means indicating the actual order of development. As in the case of the mesenteries, the radial plan of the mature or less definite dorso-ventral or antero-posterior succession. Furthermore, as in the case of the tentacles, the exosepta remain exosepta throughout the course of their development, always constituting the outermost cycle. The entosepta beyond the primary six follow the same succession of growth as the mesenteries, so that the order assigned the secondary and tertiary mesenteries in figure 13 will also hold for the septa.

EXTINCT CORALS

Studies on the septal development of the extinct Paleozoic corals, known as the Rugosa or Tetracoralla, reveal that in these early forms the primary septal plan was hexameral, like that of modern forms, but the later septal development is altogether different from anything found in recent corals. The metasepta appear in successive bilateral pairs, within only four of the six primary interseptal chambers, and the corallite retains a bilateral symmetry throughout its developmental stages, though afterward it may attain radial symmetry. Only two cycles of septa are ever present, a larger and a smaller (dicyclic), though some members of the primary cycle may differ in size from the remainder. The larger septa are entosepta and the smaller exosepta; only the former have any definite ordinal significance, the exosepta appearing at different times in different species.

On account of the manner of appearance and arrangement of the septa the Rugosa must be clearly separated from modern hexamerous, polycyclic Madreporaria; of all the living zoantharians they are most septa is derived from structures which appear bilaterally, in a more closely related to the zoanthids among the actiniarians.

SUMMARY

The studies thus briefly outlined enable the relationships of madreporarian coral polyps to be determined with much precision. With the exception of the characteristics dependent on the presence of a skeleton, they present no feature which separates them from ordinary hexameral actinians. The development and arrangement of the mesenteries and the tentacles, in both the protocnemic and metacnemic stages, are the same in both groups. In the absence of siphonoglyphs from the stomodæum, and of lateral ciliated bands from the mesenterial filaments, coral polyps differ from the great majority of anemones, but some of the lower actinians are without siphonoglyphs and have but simple filaments. Modern Actiniaria (excluding the Ceriantheæ and Zoantheæ) and Madreporaria constitute a single group, one section of which forms a skeleton while this is absent in the other. On the other hand the Paleozoic rugose corals diverge from modern corals after the formation of the six primary septa, their septa are then added in the same sequence as are the mesenteries in the Zoantheæ; further, the single ventral siphonoglyph of the zoanthids was probably present in the rugose polyp, being now represented in the skeleton by the fossula. The Rugosa and Zoantheæ undoubtedly constitute a common group of skeleton-forming and skeletonless polyps, just as do the modern Madreporaria and ordinary hexamerous Actiniaria.

Modern Madreporaria may be defined as follows:

Madreporaria

Anthozoa of which the polyps are either simple or colonial. The basal ectoderm gives rise to a continuous external calcareous skeleton, usually consisting of basal, peripheral, and radial elements. Colonial polyps are in communication at the proximal termination of the column, and sometimes by basal canals ramifying through the skeleton. Tentacles in alternating cycles, often with a knobbed or swollen apex. Stomodæum smooth or ridged, without gonidial grooves or siphonoglyphs. The mesenteries include a primary cycle of six pairs, appearing successively in bilateral pairs, two pairs of which are directives, and usually a second series which arise antero-posteriorly as isocnemic exocœlic pairs all round, becoming arranged in cycles. Mesenterial filaments simple, without lateral ciliated bands. Lower region of gastro-cœlomic cavity subdivided by septal invaginations, alternating with the mesenteries, sometimes perforated by skeletal growths. Reproduction sexual and asexual; asexual reproduction frequent, by gemmation and fissiparity.

DESCRIPTIONS OF SEVEN NEW SPECIES AND SUB-SPECIES OF BIRDS FROM TROPICAL AMERICA

By ROBERT RIDGWAY

The following new forms are included in Part IV of *Birds of North and Middle America*, now in course of preparation by the United States National Museum, and are published in advance of that volume, the appearance of which cannot be expected during the present year.

1. MYADESTES GENIBARBIS CHERRIEI new subspecies

Similar to *M. g. sanctæ-luciæ* but under parts paler, white on lateral rectrices less extended, and eighth primary more attenuate and falcate at tip.

Mountains of eastern portion of island of Haiti (Santo Domingo).

Type, No. 655, Field Columbian Museum, adult male, Catare, Santo Domingo, February 5, 1895; Geo. K. Cherrie, collector.

2. CATHARUS FUSCATER SANCTÆ-MARTÆ, new subspecies

Similar to *C. f. hellmayri* Berlepsch, but gray of throat quite uniform with that of chest, and under tail-coverts clear slate-gray or mouse-gray, like color of sides and flanks, instead of dull brownish buff or wood-brown.

Santa Marta district of Colombia.

Type, No. 8,797, coll. Carnegie Museum; Elheibano, Colombia, April 22, 1899; Mrs. H. H. Smith; adult male.

3. CICHLHERMINIA CORYI, new species

Differing from all other forms of the genus in having very large, broad, roundish ovate spots of white on chest, the brown margins of these feathers darker.

Locality unknown, but supposed to be island of Martinique, Lesser Antilles.

Type, No. 3,618 Lafresnaye collection, in coll. Boston Soc. Nat. Hist.

4. CINCLOCERTHIA RUFICAUDA TENEBROSA, new subspecies

Similar in size to *C. r. ruficauda* (of Dominica) but much darker above, the pileum deep sooty gray, back sooty brown, remiges and rectrices chestnut-brown; chest more strongly and extensively grayish.

Island of St. Vincent, Lesser Antilles.

Type, No. 74,060, coll. U. S. Nat. Mus., adult male; St. Vincent, Lesser Antilles, February 8, 1878; F. A. Ober.

5. CINCLOCERTHIA RUFICAUDA PAVIDA, new subspecies

Similar in coloration to *C. r. ruficauda* but much larger (adult male averaging wing 101.9, tail 91.3, exposed culmen 30.1, tarsus 30.5; adult female, wing 96.5, tail 83, exposed culmen 36, tarsus 30.2).[1] Size of *C. r. tremula* (of Guadeloupe), but coloration much paler.

Islands of St. Christopher, St. Eustatius, Saba, Montserrat, Nevis, and Barbuda, Lesser Antilles.

Type, No. 80,925, coll. U. S. Nat. Mus., St. Christopher, Lesser Antilles; F. A. Ober.

6. MIMUS GILVUS GUATEMALENSIS, new subspecies

Similar to *M. g. columbianus* (Cabanis) but outer webs of primaries white basally, forming a distinct patch beneath the primary coverts (sometimes partly exposed beyond tips of the latter); gray of upper parts slightly browner; wings and tail decidedly blacker, the middle (as well as greater) wing-coverts abruptly tipped with white;[2] white of under parts less pure, the chest pale buffy grayish, the flanks and under tail-coverts more strongly buffy.

Highlands of Guatemala and Chiapas and adjacent parts of Tabasco and southern Vera Cruz (Coatzacoalcos).

Type, No. 150,906, coll. U. S. Nat. Mus., adult male; Capetillo, Department of Suchitépequez, southern Guatemala, November 18, 1890; Heyde and Lux.

7. MIMUS GILVUS TOLIMENSIS, new subspecies

Similar to *M. g. columbianus* but much larger, and with whole of loral and subocular regions and most of auricular region dusky.

Adult (*male* ?).—Length (skin), 253 mm.; wing, 128; tail, 140; exposed culmen, 22; tarsus, 35; middle toe, 25.5.[3]

Southwest-central Colombia, in State of Tolima.

Type, No. 35,356, coll. Acad. Nat. Sci. Phila.; Plain of Tolima, Colombia; Detwiller collection.

---

[1] Corresponding measurements of *C. r. ruficauda* (confined to the island of Dominica) are: Adult male: Wing, 94.6; tail, 79.5; exposed culmen, 28.2; tarsus, 28.4. Adult female: Wing, 90.7; tail 76.5; exposed culmen, 32.2; tarsus, 28. (Measurements in millimeters.)

[2] Except in much worn "midsummer" plumage.

[3] The maximum and average measurements (the latter in parentheses) of six adult males of *M. g. columbianus* from the State of Santa Marta are as follows: Length (skins), 245 (231); wing, 118.5 (113.7); tail, 122 (116); exposed culmen, 20.5 (19); tarsus, 35.5 (34.2); middle toe, 23 (21.6).

AN HISTORICAL AND SYSTEMATIC REVIEW OF THE FROG-SHELLS AND TRITONS

BY WILLIAM HEALEY DALL

Everyone who has looked upon the numerous "triumphs of Galatea," "births of Venus," and "processions of Neptune," in European picture galleries, scenes dwelt upon by mediæval painters, has noticed the large, twisted, and variegated shells which are the invariable wind-instruments of the lusty Tritons who form the chorus around the sea-born deities depicted. These shells, the "Buccina" of the ancients, became naturally in popular speech the "Triton-shells," and finally the "Tritons" of the conchologist. Even at the present day on many an Italian hillside the sonorous note of these shells, blown by the peasants, serves to call the cattle home at dusk; and they may even be heard occasionally on the alien farms of New England, in use for the same purpose, or as dinner horns.

The elegant denticulation of the outer lip of these shells was copied in ages past by the silversmith, and the special conventional type of ornament thus derived has a name of its own, "gadrooning."

Related to the Tritons is another group of shell-bearing mollusks, variously known to eighteenth century conchologists as "frogs" (from their tubercular ornamentation) or "purses" (from their swollen oval form) and, since the development of a scientific nomenclature, by the more attractive names of *Ranella* or *Bursa*.

The history of the classification of these shells is very complex and has never been fully elucidated. The clearing up of some of the obscurity which has enveloped them and the proposal of a more modern and accurate system of classification for the two groups, is the object of this paper; in which the author has availed himself of the labors of many worthy predecessors, and, it is hoped, has made some advance on their conclusions.

I. NOTES ON RANELLA AND ITS ALLIES

The first attempt definitely to segregate from the heterogeneous Linnéan Murices the group already popularly recognized under the name of "Frog shells," or "Purses," was made in the anonymous Museum Calonnianum in 1797. Here they were called *Rana*, a name already in use for the batrachian referred to. The following year

Bolten's posthumously printed catalogue appeared, in which the same group was recognized under the name of *Bursa*. *Murex rana* Linné was separated into some of its component species, beginning with *rana* s. s. Bolten (*spinosa* Lamarck) and including *R. crumena* Lam., *R. foliata* Brod., *B. gibbosa* Bolten (*R. granulata* Lam.), *B. mammata* Bolten (=*M. bufonius* Gmelin, 1792), and *B. bufonia* Bolten not Gmelin (=*spinosa* var.). These are all forms with a posterior canal at the junction of the outer lip and body whorl, and the group includes both nodular and spinose forms. The forms without a posterior sinus, and with or without laterally uniform varices, are put in *Tritonium* Bolten (not Müller) just as was done nearly a century later by Fischer. Owing to the confusion of allied species with one another by Linné, Gmelin, and other early writers, it is necessary to be very careful in making the identifications upon the accuracy of which so much depends.

The next author to take up the group was Link in 1807, whose classification was less natural than Bolten's, since it seems to have been based wholly on the presence of symmetrical lateral varices, and included species like *M. gyrinus* Linné, which have no posterior canal. He includes under the name of *Gyrineum*: *G. echinata* Link (*R. spinosa* Lam.); *G. rana* (L.) Link (*R. crumena* Lam.); *G. bufonium* (Gmelin) Link; *G. natator* Link (*R. tuberculata* Broderip); and *G. verrucosum* Link (=*R. ranina* Lam. =*Murex gyrinus* L.). This retrograde arrangement has been more or less popular up to the present moment.

Montfort in 1810, saw more clearly and put the ranelliform Tritons by themselves under the name of *Apollon* (which he supposed to be Latin) with *Murex gyrinus* (Linné) Gmelin as type. In his synonymy, as with all the early authors, there is some confusion of similar species or figures of species, exactly as in the case of *Ranella granifera* Lamarck. But Montfort's figure, though rude, is obviously destitute of any anal sinus or gutter, and he adopts the specific name *gyrinus* for his species, identifying it with *Murex gyrinus* of Linné, better known as *Ranella ranina* Lamarck, a species known to be destitute of the anal sulcus. Moreover he contrasts it with the next genus, *Buffo*, which possesses a sinus. I think therefore we cannot do otherwise than recognize that *Apollon* is based upon the Tritonoid forms without an anal sulcus, and accept literally his cited type as the type of Montfort's genus, in spite of the fact that incongruous species are included among those cited in his synonymy.

Very much the same is true of *Ranella granifera* Lamarck, among the synonyms of which are species with and species without an anal sulcus. The species which is adopted by Fischer to bear the name of *granifera,* has a shallow sulcus, removed from the vicinity of the suture, and belongs in the section *Colubrellina* Fischer, as recognized by Cossmann. This latter identification would place *R. granifera* (Lam.) Fischer, among the *Ranellas,* but it cannot be taken as typical, since Bowdich and Blainville had both selected as the type, from among Lamarck's species, the *R. bufonia* Gmelin, which must be retained in that capacity, since Lamarck himself did not select any type, and Bowdich, his friend and pupil, prepared his "Elements" under the supervision of the elder naturalist. If any one were disposed to fall back on the "first species" they would be obliged to accept *R. crassa* Dillwyn, as that is the type of Montfort's *Buffo* referred to by Cuvier first in the list he gave on the occasion of the first publication of the genus *Ranella;* the French *Ranelle* of 1812 being an absolutely "nude" appellation, not entitled to recognition.

For the *Bursa* of Bolten Montfort proposed the name *Buffo* (not *Buffo* Lacépéde, 1788) with *B. spadiceus* (= *M. crassus* Dillwyn or *R. granulata* Lam.) as type. In 1811 Perry gave the name *Biplex* to a group which is the equivalent of *Gyrineum* Link, but which has been retained by Fischer in a sectional sense for the *Biplex perca* of Perry, a remarkable compressed form, first made known in Perry's work. A year later in his Extrait d'un Cours, Lamarck indicated his genus by the nude vernacular name of "*Ranelle,*" which was introduced into nomenclature by Cuvier, in 1817, under the Latin form of *Ranella.* Cuvier adopts Montfort's *Apollon* and for the preoccupied *Buffo* substitutes *Ranella,* as of Lamarck; and gives a list of species which makes Lamarck's genus the equivalent of the earlier *Gyrineum.*

In the same year Schumacher proposed a genus *Bufonaria,* which is the equivalent of Montfort's *Buffo,* section *α* being typified by *R. spinosa* Lamarck, and section *β* by *Murex scrobilator* Linné. For the tritonoid form called *Ranella gigantea* by Lamarck, he proposed a genus *Gyrina* (not *Gyrinus* Linné, 1767); and for another, *Murex lampas* Linné, the genus *Lampas* (not *Lampas* Montfort 1808), which is practically identical with *scrobilator* in general characters.

Lamarck made his own first publication of the name *Ranella* in the seventh volume of the Animaux sans Vertébres, 1822, after he had become blind, and in the same year his pupil and friend, Bowdich, in the first part of his Elements of Conchology, cites as his sole example or type of the genus *Ranella,* the *R. bufonia* Gmelin.

Three years later Blainville in his Manual divides the genus into two groups, *Ranella* s. s. with *R. granulata* as type[1] (= *R. bufonia* as figured), and *Apollon* Montfort, with *Ranella ranina* Lamarck, cited as type, and *R. gigantea* Lamarck figured as an example.

This practically brings us to a point where we can sum up the status of these older names before taking up more modern treatment of the group and its subdivisions. It seems that we have, in the Tritoniens of the older writers, two groups which have developed in a somewhat parallel manner: one, in which varical periodicity is generally irregular but sometimes regularly restricted to half a circuit of the columellar axis, and in which there is no anal canal in the aperture; another, in which the varices occur almost always regularly but in which there is always an anal sinus, sometimes conspicuously produced in the form of a guttered spine. This distinction was recognized by Bolten, Montfort, and Blainville, among the older writers, and emphasized by Jousseaume and Fischer among the modern systematists. I am inclined to accept this view as being the most satisfactory method of dividing a somewhat puzzling family.

It is evident that the first available name for the group typified by *Murex rana* (L.) Bolten, is *Bursa* Bolten, and that this must be adopted for the genus. Eliminating from Link's group the species properly belonging to *Bursa* we have *Murex gyrinus* Gmelin, left to carry Link's name *Gyrineum,* of which *Apollon* Montfort will be a synonym. *Biplex* Perry may be reserved for one of the subdivisions of *Gyrineum.* The subdivision α of Schumacher's *Bufonaria* is typical *Bursa,* but for the subdivision β typified by *Murex scrobilator* Linné, the name may be retained; *Lampas* Schumacher (not of the Museum Calonnianum or H. and A. Adams) and *Tutufa* Jousseaume, are synonymous. If *Gyrina* Schumacher is regarded as preoccupied by *Gyrinus* Linné, the group so designated must be given a new name.

H. and A. Adams were the next authors to modify the nomenclature of the group to which they added the subgenus *Aspa* and also reinstated *Bursa* and revived the prelinnean *Argobuccinum* for *Murex argus* Gmelin and its allies. Otherwise they rather added to than diminished existing confusion.

In 1881 Jousseaume took up the group with a keen eye for distinctive characters. If his researches had carried him far enough to discover the original types of the different named groups, and he had arranged his system accordingly, this author might have had the gratification of finally systematizing the group. But as it was he

[1] Not *R. granulata* of Lamarck.

seems to have chosen types at random for the old names, as if none had been selected before him. His arrangement thus applied the old names to wrong groups, necessitating revision. The group containing *R. ventricosa* Broderip, and *R. californica* Hinds, he named *Crossata*, to *Lampas* Schumacher (but not of the Museum Calonnianum) he gave the new name *Tutufa*, and to the small Ranellas with short anal tube, the name *Lampasopsis* later corrected by Fischer to *Lampadopsis*. Fischer, in 1884, accepted in the main the arrangement of Jousseaume, substituting *Colubrellina* for the name *Colubraria* Jousseaume *non* Schumacher.

Cossmann, in 1903, returned to the point of view of Link and Adams with results which cannot be regarded as happy.

The Ranellas or Bursas shade very gradually into the forms formerly known as *Triton* or *Tritonium*, judged by most of their characters, but the use of the anal sulcus as a distinctive character enables us to differentiate the two groups. In preparing a key to the subdivisions of *Bursa* it was found necessary to propose two sectional names, *Marsupina* for the restricted *Buffo* of Montfort, and *Chasmotheca* for the elegant *Ranella foliata* of Broderip and its allies. Those who prefer to consider species in large masses will properly ignore the sectional divisions, but others will find the closer subdivisions convenient on many occasions, and, since several of them were named by authorities so respectable as Lamarck and Fischer, I have been tempted to make the system symmetrical. The following key will enable any one to refer any of the true Bursas to its proper section. The species destitute of a posterior anal canal are not considered in this arrangement.

Family RANELLIDÆ

Genus BURSA Bolten

Subgenus BURSA s. s.

- Shell with the spire elevated and surface sculptured.
  - Operculum with lateral nucleus.
    - Varices uniformly lateral and continuous.
      - Anal sinus at the suture, short.
        - Shell thin, without a continuous callus on the body.
          - Varices spinose. Sect. *Bursa* (*spinosa* Lam.).
          - Varices crenate. Sect. *Marsupina* (*spadicea* Mtf. or *crassa* Dillwyn).
      - Anal sinus extended as a gutter on the body.
        - Body with a continuous rugose callus with elevated margin.
          - Varices subspinose. Sect. *Chasmotheca* (*foliata* Broderip).

Operculum with apical nucleus.
Varices lateral and continuous.
Anal sinus subtubular, at the suture.
Body with a continuous appressed rugose callus.
Shell heavy, nodulous.
Anal sinus produced. Sect. *Ranella* (*bufonia* Gmelin).
Anal sinus short. Sect. *Lampadopsis* (*rhodostoma* Beck).
Varices variable, usually lateral and continuous.
Shell thinner, granulous.
Anal sinus shallow, short. Sect. *Colubrellina* (*conditus* Gmelin).
Subgenus Aspa H. and A. Adams.
Shell with the spire depressed.
Varices uniformly lateral, smooth.
Anal sinus produced as a gutter on the body.
Shell thin, smooth. *Aspa* (*marginata* Gmelin).
Subgenus Bufonaria Schumacher.
Shell with elevated spire and sculptured surface.
Varices not uniformly lateral.
Anal sinus short, at the suture.
Surface sparsely tuberculous.
Shell thin, body callus smooth, appressed. Sect. *Crossata* (*ventricosa* Broderip).
Varices feeble, irregularly disposed.
Body callus continuous, rugose, with raised margin. Sect. *Bufonaria* (*scrobilator* Linné).
Shell with elevated spire and prominent sculpture.
Varices irregular, sharp, elevated, crenate.
Anal sinus shallow, its fasciole tabulating the whorls.
Sculpture reticulate, the spirals stronger, continuous.
Body callus thin, with elevated margin, smooth.
Canal strongly recurved. Sect. *Craspedotriton* Dall, nov. Type, *Triton convolutus* Broderip.

The following synonymy will enable one to follow the fluctuating nomenclature of the group, though not intended to be exhaustive.

Genus BURSA Bolten

Murex (sp.) Linné, Syst. Nat., ed. x, p. 748, 1758.

Rana (Anonymous), Mus. Calonnianum, p. 33, 1797. *M. scrobilator* and *M. rana* L. cited. Not Rana L. 1758.

Bursa Bolten, Mus. Bolt., p. 128, 1798; 1st sp. cited *B. rana* Bolten (= *Ranella spinosa* Lam.); Mus. Bolt., ed. ii, p. 91, 1819.

Gyrineum Link, Beschr. Rostock Samml., p. 123, 1807. Includes species of *Bursa* and *Murex gyrinus* Gmelin + *Ranella ranina* Lam.

Biplex (sp.) Perry, Conch., expl. pl. iv, v, 1811.

Buffo Montfort, Conch. Syst., ii, p. 575, 1810; *B. spadiceus* Mtf. = *Murex crassa* Dillwyn + *Ranella granulata* Lamarck.

Bufonaria Schumacher, Essai, p. 251, 1817; *α Ranella spinosa* Lam. (*M. rana β*, L.); *β*, *M. scrobilator* L.

Lampas SCHUMACHER, Essai, p. 252, 1817, *Murex lampas* LINNÉ, not *Lampas* MONTFORT, 1808.

Ranelle LAMARCK, Extr. d'un Cours., p. 118, 1812; nude name.

Ranella (sp.) CUVIER, Régne Anim., II, p. 540, 1817; LAMARCK, Anim. s. Vert., VII, p. 149, 1822, no type selected.

Ranella BOWDICH, Elem. Conch., I, p. 36, pl. 10, fig. 6, 1822, sole ex. cited *Murex bufonia* GMELIN. Blainville, Man. Mal., I, p. 400, 1825; type cited *R. granulata* BLAINVILLE (not LAM.) = *R. bufonia* GMEL.

Bursa H. and A. ADAMS, Gen. Rec. Moll., I., p. 105, 1853.

Renella SOWERBY, Conch. Ill., 1841, *ex parte*.

Ranella JOUSSEAUME, Bull. Soc. Zoöl. France, VI, p. 173, 1881, *R. crumena* LAM., cited as type.

Bufonaria JOUSSEAUME, *op. cit.*, p. 174, *R. spinosa* LAM.

Bursa JOUSSEAUME, *op. cit.*, p. 174, *R. bufonia* GMEL.

Colubraria JOUSSEAUME, *op. cit.*, p. 174, *R. candisata* REEVE, not *Colubraria* SCHUMACHER, 1817.

Lampasopsis JOUSSEAUME, *op. cit.*, p. 175, *R. rhodostoma* BECK.

Colubrellina FISCHER, Man. Conch., p. 656, 1884; *R. candisata* REEVE.

Lampadopsis FISCHER, Man. Conch., p. 656, 1884; *R. rhodostoma* BECK, corr. *Lampasopsis.*

Ranella FISCHER, Man. Conch., p. 656, 1884; *R. crumena* LAM.

Gyrineum ROVERETO, Atti Soc. Ligustica, X (extr. p. 6), 1899; type *Murex spinosus* DILLWYN (= *Bursa* BOLTEN).

Ranella ROVERETO, *op. cit.*, type *R. crumena* LAM.

Pseudobursa ROVERETO, *op. cit.*, type *Murex bufonia* GMELIN (= *Ranella* LAMARCK, s. s.).

Biplex ROVERETO, *op. cit.* (p. 7), type *R. siphonata* REEVE (= *Ranella* LAMARCK, s. s.).

Apollon COSSMANN, Essais de Pal. Comp., V, p. 115, 1903; type *Ranella granifera* LAM. (= *Colubrellina* FISCHER); not *Apollon* MONTFORT, 1810.

Bufonaria COSSMANN, op. cit., p. 117, 1903. *Ranella spinosa* LAMARCK (= *Bursa* BOLTEN, s. s.).

Aspa COSSMANN, *op. cit.*, p. 118, 1903, = *Aspa* H. and A. ADS.

Tutufa COSSMANN, *op. cit.*, p. 89, 1903, *Murex lampas* LINNÉ; (= *Lampas* SCHUMACHER, 1817, not of MONTFORT, 1808; + *Bufonaria* β SCHUMACHER, 1817; + *Tutufa* JOUSSEAUME, 1881). = *Bufonaria* s. s.

Crossata COSSMANN, *op. cit.*, p. 89, 1903; *Ranella ventricosa* BRODERIP; (= *Crossata* JOUSSEAUME, 1881).

Pseudobursa COSSMANN, *op. cit.*, p. 89, 1903.[1] Type *Murex bufonia* (LINNÉ) GMELIN. (= *Ranella* s. s.).

The incongruous forms which have been associated with *Bursa* or *Ranella* must be somewhat widely distributed.

[1] The proposition to replace *Bursa* by *Pseudobursa* is nullified by the fact that Petiver, and Bonanni are both prelinnean authors, and their polynomials are without standing in nomenclature.

Some years ago I showed that *Aspella* Mörch must be referred to the *Muricidæ,* near *Trophon.*[1]

Still earlier Stimpson had shown that a similar disposition must be made of *Eupleura,*[2] which seems to be nearly related to *Ocinebra.* Ever since Montfort's time a certain proportion of naturalists have recognized the distinction between the groups typified by *Bursa* and *Gyrineum* or *Apollon.* Quite recently Kesteven in a very excellent review of *Lotorium*[3] has thrown much additional light upon the subject.

The writer in some earlier publications, not having been able to review the whole history of the nomenclature of this family, used names in the sense in which he found them used by Mörch and others in the literature, and for some years urged the rejection of undefined generic names, and of some works as authorities, which did not seem to him to have been actually published in the strict sense of the word. Recognizing, however, during the years which have elapsed, that the consensus of opinion is that such names should be accepted and several of the works are entitled to citation, in more recent work he has endeavored to conform to the current practice of specialists in zoölogical nomenclature. This explanation seems due to explain some discrepancies of treatment in the nomenclature of certain genera, when earlier and later papers are compared.

II. Notes on Triton and Its Allies

Very soon after the publication of the tenth edition of the Systema Naturæ it became evident that further subdivision of some of the Linnean genera would be necessary, as well as certain changes in the general features of their classification. The first move, however, due to O. F. Müller, was, so far as the present family is concerned, a consolidation in which were included *Buccinum, Murex,* etc., of Linné, in fact by implication all the canaliferous Prosobranchs, under a new name, *Tritonium.* This was contrary to the rules of nomenclature and the name cannot be used, although it was accepted by Bolten, Link, Cuvier and various other authors for a portion of the species included under it. The first binomial author to subdivide our group was Bolten, the names used by Klein being prelinnean and polynomial, and only quotable historically. Bolten included a majority of the Lamarckian Tritons under the name *Tritonium,* begin-

[1] Report on Gastropoda of the "Blake," *Bull. Mus. Comp. Zool.,* XVIII, No. XIX, pp. 206–10, 1889.

[2] *Am. Journ. Conch.,* I, p. 58, 1865.

[3] *Proc. Linn. Soc. N. S. Wales,* XXVII, part III, pp. 443–483, Dec., 1902.

ning with *Murex tritonis* Linné, and covering also a number of the ranelliform Tritons and at least one *Ranella* (*R. candisata* Ch.). Following this, *Bursa* is proposed, as previously noted, for the true Ranellas, and is followed by *Cymatium*,[1] beginning with *Murex femorale* Linné, and including several other species with a long canal. Lastly *Cabestana* Bolten is proposed for species with a short canal, strong spiral ridges, and rather stout whorls, beginning with *Murex cutaceus* Linné, and including *Triton doliarium, Purpura trochlea,* and *Ocinebra erinacea* Lamarck. The related genus *Distorsio* is proposed by Bolten for two groups: (1) *Caudatæ,* containing *Murex anus* Gmelin, and its allies; and, (2) *Truncatæ,* including Nassas of the group of *N. arcularia.*

Link in 1807, has only three groups: *Tritonium* which is practically identical with *Tritonium* Bolten; *Distortrix* which is equivalent to the first section of *Distorsio* Bolten, thus leaving the Nassas to bear Bolten's name; and *Gyrineum* which is equivalent to *Bursa* Bolten, + the ranelliform Tritons. *Murex gyrinus* Linné, for which the name *Gyrineum* must be reserved; *Ranella tuberculata* Broderip, and *R. ranina* Lamarck, are cited from Martini's plates. I may mention here that the work of Link appears to have been known to Lamarck, who adopts at least one of his genera, and to have been somewhat more widely distributed than I had been led to believe when I printed my remarks upon it in 1876 and 1889.

The next author to concern himself with the divisions of this group was Denys de Montfort, the second volume of whose "Conchyliologie" appeared in 1810 (not 1808 as cited by Kesteven). As he cites and figures but one species in each case, but little question can arise as to the identity of the type. Besides *Apollon,* which has already been discussed, he proposed *Aquillus* for *Murex cutaceus* Linné (= *Cabestana* Bolten); *Lotorium* for *Murex "Lotorium* Linné," but the species which he figures is *M. femoralis* Linné (as both belong to the same section of the genus, this does not matter much, and the group is identical with *Cymatium* Bolten); and, lastly, *Triton,* for *Murex tritonis* Linné, with which, like most authors of his time, he confuses several species; the one he actually figures being *Triton australe* var. *β* of Reeve, coming, as Montfort states, from New Zealand. The name *Triton* having already been used generically by Linné and Laurenti, for other animals, is not available. In 1811 Perry published his Conchology, in which a number of new names are proposed, but no types selected. The

[1] Not *Cymatium* Link, 1807, which is a compound of *Latirus* (*polygonus* and *lineatus* Lamarck and *craticulatus* Gmelin) and *Vasum capitellum* Linné.

first, *Monoplex* contains five species with a single varix on the body, of which two may be identical with *Triton retusum* and *T. clavator* Lamarck, one is allied to *T. olearium* (L.) Reeve, and was selected as type by Gray, 1847; one, *cornutus* Perry, is unidentifiable, certainly not *exaratum* Reeve, to which it has been referred. The last species is *Tudicla spirilla* Linné. Perry's second group was called by him *Biplex*, and contains a mixture of species of *Bufonaria* and *Gyrineum*. Fischer following Gray (1847) has retained the name in a sectional sense for the *B. perca* Perry, a remarkably compressed and crested form from Japan, better known as *Ranella pulchra* Gray. His third group, *Septa*, is also a mixture of species belonging to *Cymatium* Bolten, and *Triton* Montfort, and, since the latter had up to this time no valid name, the writer in his Report on the Mollusca of Porto Rico, adopted it for the group of which *Triton tritonis* Linné has usually been regarded as the type. Perry incidentally mentions *S. tritonis* but his largest and most conspicuous species, among those he figures, is *Septa rubicunda* Perry (+ *Triton nodiferum* Lamarck) which may be accepted as the type.

Cuvier in 1817, in the Règne Animal, adopted Montfort's subdivisions, but Schumacher, in the same year, proposed an entirely new series. *Distorta* Schumacher is identical with *Distortrix* Link. *Lampusia* α Schumacher, with *Murex pilearis* Linné, as type, *Lampusia* β, with *Murex tritonis* Linné, taken together are the equivalent of *Septa* Perry. A group not noticed by previous authors is judiciously separated by Schumacher under the name of *Colubraria* with the *Buccinum maculosum* of Chemnitz as type. *Lampas* Schumacher, but not of the Museum Calonnianum, belongs with the Ranellas and is identical with Schumacher's *Bufonaria* β. *Gyrina* Schumacher is founded on *Ranella gigantea* Lamarck, and might be retained if not thought to be preoccupied by *Gyrinus* Linné. *Ranularia* α Schumacher, is founded on *Purpura gutturnium* Martini (= *Triton clavator* Lamarck) while *Ranularia* β is based on a better figure of the same species.

Lamarck, in 1822, included under the name *Triton* almost all the forms above referred to as well as two species of *Tritonidea*. Blainville includes Montfort's groups as subgenera of *Triton*, unhappily adding to them *Struthiolaria*. *Cumia* (*lanceolata* Menke) of Bivona, 1838, is a subgenus of *Colubraria*, and *Luterium* Herrmannsen, 1846, a proposed emendation of *Lotorium* due to a mistaken etymology. In 1848 Gistel proposed to substitute *Charonia* for the preoccupied *Tritonium* of Cuvier, and *Nyctilochus* for *Triton*, not being aware, apparently, that the two are synonymous. The subsequent synonymy becomes very complex from Mörch's attempt in 1852 (in which he was followed by Henry Adams in the 'Genera of Recent Mollusca' in 1853) to revive the prelinnean names of Klein. Mörch made a second attempt in 1877 but the rules of nomenclature bar out any such arrangement. Our readers may follow, in the synonymy with which this article concludes, the fluctuations of opinion as to the names to be used in this group.

In 1853 Gray, following Troschel (1852), definitely separated the Tritons and Ranellas from the *Muricidæ,* on account of their *Tænioglossate* radula, a course which has since been universally adopted.

In 1863 Troschel took up the group and finding well-marked distinctions between the characteristics of the radula in, on the one hand, *Bursa, Aspa,* and *Lampas* (Schumacher), and, on the other, *Tritonium* (Link), *Distorsio, Cymatium, Simpulum, Gutturnium, Cabestana,* and *Apollon,*—he separated the group into two families, *Ranellacea* and *Tritonacea,* and each of these into several genera. In this course perhaps too great a value was assigned to minor features of the radula, but it remains certain that two well-marked groups are extant in the assembly. Gray divided the *Tritonidæ* into four subfamilies based chiefly on differences in the operculum. We may at least divide them into two subfamilies, each containing several minor groups, utilizing for this purpose the characters of shell, dentition, and operculum, besides those of the larval stages where they are known.

In 1881 Jousseaume attempted a new and purely conchological classification, not without merit, and the last discussion of importance is by Kesteven in 1902, where valuable data as to the larval shells are put on record, and a classification by unnamed conchological groups is attempted. This kind of an arrangement however is less convenient than one in which the group is not only recognized but is given a name. The difference is analogous to that between polynomial and binomial nomenclature. Sometimes it happens that, in very large groups the clustering of certain forms around certain others, all of which are connected by intermediate gradations, may be expressed in this manner; but in most cases it would seem that it is less inconvenient to ignore such nebular groups altogether, so far as the nomenclature is concerned, or to give them sectional names by which they can be handled easily.

The last attempt at an arrangement of the family is by M. Maurice Cossmann, in his Essais de Paléoconchologie Comparée, v, December, 1903. In this the author returns to the ancient confusion caused by regarding the varices and their position as a fundamental character, and his work is still further complicated by a number of errors in the matter of determining types. Nevertheless M. Cossmann elucidates several groups which had been overlooked and by his figures and descriptions lends aid to those who desire to study the group more thoroughly. A full analysis of his arrangement will be found in the ensuing nomenclatorial table.

The Tritons are nearly allied to the Ranellas and to *Dolium*, representing among the *Tænioglossa* a group analogous to the Murices among the *Rhachiglossa*. Their origin is traced to the Cretaceous where are found some relatively small and delicately sculptured shells having an external resemblance to *Fusitriton*, and possessing varices which are irregularly distributed and more prominent internally than externally, leaving on the surface of the internal casts axial sulci. This genus named by Meek *Trachytriton* has been with much plausibility suggested to be a precursor of the Tritons. This is of course hypothetical since the dentition and the operculum can never be known, yet it is to some extent supported by the presence in the Claibornian Eocene of a somewhat intermediate type, the *Ranellina maclurii* of Conrad. In this form, while the varices are most prominent internally, they are also well marked externally; the nucleus, though small, is of the tritonoid type, while the spirally striated shell has the general form of *Trachytriton*, rather fusoid than torticular.[1]

In the later Eocene the Tritons attained a well characterized development, though the species are mostly of small or moderate size, with the canal short, sometimes abruptly recurved, and the sculpture more or less cancellate or nodulous, but usually more delicate than that of the Neocene or living forms. An indication of the characteristics of what, in later geological time, became well-marked genera, is frequently perceptible; as in the *Personella* of Conrad (*P. septemdentata* Gabb, of the Texan Eocene), which, though without the characteristic lobe on the pillar and the wide spread callus on the body whorl, has yet so much of the aspect of the Miocene and Recent *Persona* (Montfort, $=$*Distortrix* Link) as to have been referred to the latter genus by M. Cossmann. *Persona*, or *Distortrix*, was fully evolved by the time the sedimentation of the lower Oligocene took place in America, a characteristic species, *D. crassidens* of Conrad, appearing in the Oligocene.

In the Miocene Tertiary quite a full representation of the group

[1] I do not know why M. Cossmann supposes that this species has never been found since Conrad's time. It is not common but has been repeatedly collected at Claiborne. A short variety of it seems to have been described by Whitfield as *Pisania claibornensis* (*Am. Journ. Conch.*, I, pl. XXVII, fig. 2, 1865).

occurs, nearly every recent sectional group being found illustrated by some Miocene species. The only exceptions known to me are the southern type of *Priene,* and *Lotorium* s. s., which seem, so far, to have been recognized only in the recent state. It should be noted that the southern forms referred by Kesteven to *Lotorium,* for the most part exhibit very peculiar characters in the protoconch. Of the Australian species figured by him only two (figs. 7 and 8) seem to have a protoconch in the least resembling that of the typical group. It is probable therefore that Cossmann is justified in segregating *Austrotriton* and *Semitriton* from the common type.

In considering the arrangement of the members of the group the dentition, the protoconch and nepionic shell, and the operculum must all be considered in any natural arrangement, and with the possible exception of the last are all more important than the conchological sculpture and form. I regard the number and arrangement of the varices as of very little systematic importance, and the defects of M. Cossmann's arrangement are largely due to his depending too much upon this essentially superficial character, which is, at most, of sectional value.

For the dentition of members of this group we depend chiefly upon the data furnished by Troschel. He has shown that the Ranellas are distinguished from the Tritons very much as is *Cassis* from *Dolium* by characteristic features of the radula. The Ranellas have a rhachidian tooth which is narrow but arcuate and laterally produced, generally with a central large and several small lateral denticles on the cusp and on the base a prominent recurved dentiform plate on each side. In the latter character they agree with *Dolium.* The Tritons, however, have a rhachidian tooth less extended laterally, not at all or very slightly arcuate on the base and without basal plates, in the latter feature agreeing with *Galeodea* and *Semicassis. Argobuccinum* (*argus*) and *Fusitriton* (*oregonensis*) have mutually similar teeth, much more similar than those of *Priene* (*scabra*) and *Fusitriton.* The latter differs from *A. argus* only in having the inner lateral simple, instead of denticulate. *Septa* is separated from the other Tritons by its laterally extended rhachidian tooth with a median inflection in front but without basal plates, recalling that of *Cassis.* The Ranellas possess no jaw or mandible, but *Cassis* and the Tritons have it well developed. The operculum is rather variable, as between the various groups, in general tending to the fusoid type with apical nucleus, especially in the Tritons, though the tritonoid *Distortrix* has the nucleus lateral about midway between the ends recalling that of *Cassis; Septa* has it subcentral and internal; *Cymatium* (*femorale*) has it long and narrow with apical nucleus; *Cabestana* (*cutacea*) concentric with nucleus subcentral; *Gyrina* (*gigantea*) ovate and slightly arcuate with the nucleus apical as if making an effort toward spirality; *Fusitriton* (*oregonensis* and *cancellata*) broad ovate with the nucleus slightly within the anterior lateral margin; *Lampusia* (*pilearis*) has it fusoid. According to Adams the Ranellas have the operculum ovate with an apical or subapical nucleus, while Gray speaks of it as half ovate with a central, lateral or internal nucleus; probably it varies in the different groups as in the tritons; in *Ranella foliata* it is figured as concentric with the nucleus mid-lateral. One cannot safely generalize on this character until the operculum of more species is known.

The protoconch and nepionic shell in the Tritons are practically continuous and inseparable, and are apparently very similar if not identical in character in both the tritonoid and ranelloid groups. In one group alone, *Septa,* is there a distinctly marked neanic stage. The nuclei of the Australian fossil forms, as figured by Kesteven, indicate that a protoconch, as distinguished from the nepionic shell, was present in some if not in all these forms: a character of much interest and importance if confirmed by a renewed study of the fossils, which are not accessible to me.

I have observed the larval stage of *Fusitriton oregonensis* swimming free in the ocean in the Gulf of Alaska some 200 miles off shore. It had a horny shell of more than three whorls with numerous spiral keels of periostracum and hardly any trace of a sulcus at the base of the pillar. The operculum was broadly triangular, pointed laterally, with the subspiral nucleus within the margin and forming half a coil. Below the posterior edge of the operculum were two short and wide epipodial lappets, separated by a sharp sulcus. The head was represented by a rather high, pointed, brown papilla above the mouth, and on each side of the body was a rather large epipodial flap or flipper, which the larva used vigorously to propel itself through the water, giving it a curious resemblance to a Pteropod. The branchia and osphradium were already almost normal, but the parts about the oral aperture very little developed. The flippers were of a bright metallic green color, rendering the little animals very conspicuous in the water. There were, as far as observed, no eyes or tentacles developed, and the foot, except as a pedestal for the operculum, hardly existed. The larval shell of *Colubrellina cubaniana* D'Orbigny, from the West Indies is heliciform, with no trace of a siphonal canal, at first distinctly umbilicated and ornamented with numerous spiral series of minute bristle-like hairs, which are soon lost. The complete nepionic shell has lost its umbilicus entirely, but has not acquired a canal, which only appears with the formation of the first whorl of the adult shell. The larval shell of *Dolium* is similar, though larger, and was even described as a species of *Helix* by C. B. Adams, half a century ago. I cannot help thinking, when we remember how large a proportion of the Tænioglossa have the aperture unsulcated, that the holostomate character of these larvæ is significant and points to the acquirement of a siphonal canal in this group as a case of convergence in development, while the early spirality of the operculum and its subsequent concentric development in *Fusitriton* show the loss of a character once characteristic of the group and an instance of what might be called negative convergence. The group to which these approximations tend is of course the muricoid Rhachiglossa with which naturalists long united the tritons.

We find however that in the completed nepionic shell of forms like *T. costatus* Born (*olearium* Auct.) a well-developed sulcus exists, and the whole shell has the appearance of a small, stumpy, horny *Astyris*. In the single operculum of this stage which I have been able to examine the form was subtriangular, concentric with the nucleus ill-defined and apparently mid-lateral. The larval shell of *Septa* is identical in general characters but is followed by a neanic stage in which the elegant granular sculpture, and the delicate rose color of the test contrast effectively with the features of the adult, though there is no very pronounced line of demarcation between the two. In all these forms, and the same is probably true of *Dolium* and its allies, the larval shell is furnished with caducous spiral lines of projecting hairs and under them is smooth and polished, or faintly spirally striated, the height of the spire depending upon the length of time the individual floated about in the larval state before finding itself in a location where it might conveniently settle on the bottom. Sometimes there may be as many as seven whorls. With the beginning of the adult type of whorl a lining of shelly matter is deposited on the inside of the horny larval shell. The latter loses first its hairy periostracum, then it may itself disintegrate, leaving the shelly internal cast at the apex of the shell, which is sometimes filled up solid with shelly matter. Sometimes the thin, horny apex of the larval shell in drying may become axially wrinkled, suggesting sculpture, but on wetting the wrinkled part it will usually expand to its normal smooth condition, leading one to reflect how easy it is to make hasty conclusions.

The verge in this group is usually elongate conic with a groove serving as a conduit, the organ is usually bent backward and often somewhat twisted when not functioning. The peduncles of the eyes are fused with the tentacles externally so that the eyes appear to be sessile on the latter some distance above the tentacular base. The proboscis is stout and retractile. The ovicapsules are deposited on shells, stones, etc., in moderate depths of water. They occur, associated in groups, though each capsule is separately placed, being usually urn-shaped or prismatic in form, taller than wide, and with a flat marginated top, through which the young issue. The capsules of *Ranella* (*californica*) are somewhat similar, but wider than high, and shaped (except for the flat top) somewhat like a thick slice of bread from a square loaf.

According to Krebs, in the West Indies *Septa* is found in twelve feet of water among seaweeds; *Cymatium* (*femorale*) on blue sandy mud near low-water mark; and such species as *T. tuberosum, labiosum,* and *pileare* in two or three feet of water among stones and coral. *Colubraria* (*lanceolata*) affects similar situations. The Ranellas of the West American coast appear (*R. californica*) in immense numbers in shallow water to spawn, at times, but not every year; and after spawning they return to depths of ten or fifteen fathoms. The tropical species, at Panama and elsewhere, are dredged in fifteen to forty fathoms. *Distortrix* on the same coast is obtained in ten to over fifty fathoms, but in the Antilles has been dredged living in more than one hundred and fifty fathoms. Indeed the shallow water situs recorded by Krebs may be merely the limit reached in spawning by many Tritons which live, as shown by the Blake dredgings, at times in depths nearly reaching one hundred and fifty fathoms and even more. On the Alaskan coast I have dredged *Fusitriton oregonensis* in four to six fathoms, but the Albatross has obtained it in depths down to one hundred and sixty fathoms. It seems to prefer a mud and gravel bottom, and is almost invariably decollate or eroded at the apex. I have never seen an adult retaining the earlier whorls intact. The Magellanic species also occurs in depths down to sixty fathoms. In general the animals of this group have their soft parts brilliantly colored, often with ocellated markings, the colors being variable in the individuals of a single species. *Septa* is an exception, the animal, in contrast to the shell, being, in all the observed species, relatively dull-colored and without delimited spots or ocelli. Couthouy thought the colors were distributed sexually within the species, but this was probably accidental in the cases he observed, as I have found no uniformity of this sort in the Alaskan species.

Accepting Troschel's division of the groups under consideration into two families, for the first of which it will be convenient to retain the familiar name *Ranellidæ,* it now becomes a question as to what we shall call the family containing the Tritons, since the names *Triton* and *Tritonium* for these Mollusks are no longer available. *Lotorium* is a synonym of *Cymatium* and need not be discussed further, so *Lotoriidæ* is out of the question. *Lampusia* was originally equal to *Septa* + *Cymatium pileare* Linné, and if retained at all must be as merely a subordinate section of that genus. Hence, according to the rule governing such matters, it is not suitable as a basis for the family name. The shells forming the genus *Septa* have always been regarded as the typical triton shell and have been so denominated colloquially for two centuries. Though the number of species is not large they attain as individuals a larger size than species of any other group in the family, and indeed are among the largest and most widely distributed gastropods. There seems therefore to be no reason why the family name *Septidæ,* which is shorter and more euphonious than a name which might be formed from *Cymatium,* should not be adopted as suggested by me in 1901.

I have not found that Mr. Kesteven's groups, when tested by comparing the species, could be accepted without some transfers, as indeed he himself suggests may be necessary, but, in the main, they are sufficiently natural. An absolutely final arrangement could be attained only by making a critical study of the nomenclature and characteristics of each of the known species, which would be a work of years. The following grouping, utilizing the names on record, will, however, serve as a step in advance of the present state of the subject. I preserve the geological order.

Family SEPTIDÆ

Genus TRACHYTRITON Meek, 1864

Type *T. vinculum* Hall and Meek. Cretaceous.

Genus PERSONELLA Conrad, 1865

Type *P. septemdentata* Gabb. Eocene. Recent analogue *Triton quoyi* Reeve. Synonyms: *Sassia* (*apenninica*) Bellardi, 1873; *Semiranella* De Gregorio, 1880.

It is impossible to say whether the very close similarity in nucleus, size, and shell characters between the fossil types and *T. quoyi,* indicates the persistence of all the characters over such an enormous period of time, but without some evidence to the contrary we are perhaps justified in provisionally assuming it to be so. The Eocene

Monocirsus Cossmann, 1903, seems more closely related to this group than to *Hilda* with which he has placed it. It looks like a precursor of *Linatella*.

Genus RANELLINA Conrad, 1865

Type *R. maclurii* Conrad. Claiborne Eocene. Synonym: *Sanclina* Conrad, 1865, a typographical error. This type is extinct, so far as known.

Genus AUSTROTRITON Cossmann, 1903

Type *Triton radialis* Tate. Tertiary of Australia. No recent Triton has a protoconch such as is figured for this species by Mr. Kesteven and I consider that it should be definitely separated from the species he has associated with it on this ground alone, and most of the Australian Tertiary species will naturally fall into the same group.

The groups *Plesiotriton* Fischer, 1884, and *Semitriton* Cossmann, 1903, require further examination before they can be admitted to this family. Sections should be made, to demonstrate whether there are really true plaits on the pillar lip, or whether the so-called plaits are merely lirations connected with adult formations about the aperture. In the former case *Semitriton dennanti* certainly has much the aspect and even the nucleus of one of the *Volutomitrinæ*, or *Volutocorbis*.

In this connection it may be added that the combination of *Hindsia* (*lyrata*) with this family is of doubtful validity, though it is true that a number of short tritons erroneously referred to *Hindsia* should be placed here. The conchological characters are in some respects quite similar, yet I believe that *Nassaria* or *Hindsia* was more correctly placed by Adams among the Rhachiglossa. A decision on this question must await an examination of the radula.

Triton scalariformis and *convolutus* of Broderip appear to be related to the Ranellas with irregular varices rather than to the present family, as previously pointed out. They exhibit no indications of being related to the *Muricidæ* so far as the shells are concerned. The operculum is not known to me.

Genus GYRINEUM LINK, 1807

Type *Murex gyrinus* Linné (=*Ranella ranina* Lam.). Recent. Synonyms: *Apollon* Montfort, 1810, Cuvier, 1817, and Mörch; *Gyrinea* Mörch, 1877; *Apollo* Fischer, 1883, Harris, 1897.

This includes the Tritons with continuous lateral varices. *Biplex* (*perca* Perry) Perry, is accepted as a section for species with the varices flattened and extended. The type has the operculum broad ovate, with the nucleus close to but not reaching the anterior lateral margin.

Genus EUGYRINA Dall, n. n.

Type *Ranella gigantea* Lamarck (= *olearia* Linné, *fide* Hanley). Recent. Synonyms: *Gyrina* Schumacher, 1817, not *Gyrinus* Linné, 1758; *Ranella* Cossmann, 1903.

This comprises the large thin Tritons with irregularly distributed low varices, sculptured narrow body-callus and outer lip, a slender and rather long canal, and the operculum with an apical incurved nucleus. The sculpture is tubercular.

Genus ARGOBUCCINUM Mörch, 1852

Type *Ranella vexillum* Broderip, Chile. Recent. Synonyms: *Argobuccinum* H. and A. Adams, 1858, not 1853; *Apollon* Adams, Gray, not Montfort.

Stout, dull-colored shells with dense periostracum, spiral sculpture, few and inconspicuous irregularly placed varices, and a short canal. The operculum as in *Gyrineum*.

Subgenus PARALAGENA Dall, n. n.

Type *Triton clandestinus* Lamarck. Recent. Synonym: *Lagena* Mörch, 1852, not Walker, 1784.

Shell with even spiral sculpture, a moderately long curved canal, the varix single and terminal, and the body almost destitute of callus.

Subgenus FUSITRITON Cossmann, 1903

Type *Triton cancellatus* Lamarck. Recent. Synonyms: *Argobuccinum* (sp.) Adams, *Priene* (sp.) Carpenter.

Group with the form of *Eugyrina,* the operculum of *Gyrineum,* the radula of *Argobuccinum,* and a thin cancellated shell, the species inhabiting cool temperate waters. There is no callus on the body, and very few feeble varices.

Subgenus PRIENE Adams, 1858

Type *Triton scaber* King. Recent. Synonym: *Argobuccinum* H. and A. Adams, 1853 not 1858.

Resembling *Fusitriton* but with a much shorter canal, an operculum with apical nucleus (*fide* Tryon) and a slight, more or less lirate body-callus.

Genus DISTORTRIX Link, 1807

Type *Murex anus* Linné. Recent. Synonyms: *Distorsio* (*pars*) Bolten, 1798; *Persona* Montfort, 1810, Fischer, 1883; *Distorta* Schumacher, 1817; *Cassida* Dillwyn (in syn.), 1817, not of Linné, 1767.

Genus CYMATIUM Bolten, 1798

Type *Murex femorale* Linné. Recent. Synonyms: *Lotorium* Montfort, 1810, Cuvier, Fischer, etc.; *Currus* Lesson, 1842; *Luterium* Herrmannsen, 1846.

Three-sided species with a produced canal and narrow apically nucleate operculum.

Section *Lampusia* Schumacher, 1817

Type *Murex pileare* Linné. Recent. Synonyms: *Lampusia a* Schumacher, 1817; *Simpulum* Mörch, 1852, Troschel, Fischer, etc., *Simplum* Stoliczka, 1867.

Section *Ranularia* Schumacher, 1817

Type *Triton clavator* Lamarck. Recent. Synonyms: *Ranula* Schumacher, 1817; *Monoplex* Mörch, 1852; *Ranularia* Mörch, 1852, Cossmann, 1903, etc.

This group includes the forms with a short almost turbinate spire, long and slender canal, and a heavy, mostly smooth, deposit of callus on the body continuous with that on the outer lip.

Section *Tritonocauda* Dall, *nov.*

Type *Murex caudatus* Gmelin (+ *Triton canaliferus* Lam.). Recent. Synonym: *Ranularia* Fischer, 1884, *non* Schumacher, 1817.

A group of thin shells, in form resembling *Ranularia* but with a thin wrinkled callus on the body. Operculum mid-lateral, slightly within the margin (*C. cynocephalum* Lam.) *fide* Tryon.

Section *Gutturnium* Mörch, 1852

Type *Triton tuberosum* Lamarck. Recent. Synonym: *Gutturnium* H. and A. Adams, Troschel.

Forms rather regularly fusiform, the cone of the spire and of the canal subequal, the canal moderately long, slender, strongly recurved, a heavy callus on the body.

Section *Turritriton* Dall, nov.

Type *Triton gibbosus* Broderip. Recent.

Forms with short canal and longer spire, heavy varices and flat-topped turriculate whorls.

Section *Tritoniscus* Dall, nov.

Type *Triton loroisii* Petit. Recent.

Forms with subturbinate body, short spire and canal, subumbilicate, with a single large and heavy terminal varix and narrow callus on the body.

Section *Cabestana* Bolten, 1798

Type *Murex cutaceus* Linné. Recent. Synonyms: *Aquillus* Montfort, 1810; + *Aquilus* Mörch, 1852; + *Neptunella* Gray, Adams; + *Dolarium* Schleuter, Mörch, etc.

Ample, strongly sculptured, subumbilicate, with irregular varices, short recurved canal and thin, mostly smooth callus on the body.

Subgenus MONOPLEX Perry, 1811

Type *Murex costatus* Born (= *M. olearius* Auct. *non* Linné). Recent. Synonyms: *Monoplex* (Perry) Gray, 1847, not Mörch, 1852; + *Simpulum* H. and A. Adams, 1853, not Fabricius, 1823.

Forms with the shell resembling *Cabestana* but the operculum concentric with subapical nucleus, the varices heavier, and the body-callus closely wrinkled.

Subgenus LINATELLA Gray, 1857

Type *Triton cingulatum* Lamarck. Recent. Synonyms: *Linatella* Gray; Mörch, 1852; Fischer, 1884; not of H. and A. Adams, 1858; ? + *Dolarium* Schleuter, 1837; and *Zinatella* Cossmann, 1903.

Thin Dolium-like shells, with feeble spiral sculpture and short canal, a single feeble terminal varix and inconspicuous callosities. Operculum as in *Fusitriton* and *Gyrineum*.

Genus SEPTA Perry, 1811

Type *S. rubicunda* Perry, = *Triton nodiferus* Lam. Synonyms: *Triton* (*australe*) Montfort, 1810, not of Linné, 1758; + *Tritonium* Link, 1807, Cuvier, 1817, Bowdich, Adams, Troschel, Dall, Rovereto, Cossmann, etc., not of Müller, 1776; + *Lampusia* β Schumacher, 1817; *Triton* Lamarck, 1822; + *Tritonia* Bowdich, 1822, not Cuvier, 1817; + *Charonia* and *Nyctilochus* Gistel, 1848; + *Lampusia* Mörch, 1852, Newton, Cossmann, etc.; + *Tritonellium* Mörch, 1877, not Valenciennes, 1858; + *Trompeta* Mörch, 1877; + *Buccinatorium* Mörch, 1877; + *Charonis* Mörch, 1877, in syn.; + *Lotorium* (*pars*) Kesteven, 1902.

The characteristics of this group have been already referred to at length in the text. The operculum is ovate, with a concentric, laterally subapical nucleus.

This completes the list of groups properly belonging to the *Septidæ*. There still remains, however, a group which for many years has been regarded as a genus of the Triton family, but which now appears to form a family of its own, related not to the Tritons and Frog-shells, but perhaps most nearly to the rhachiglossate genus *Tritonidea*. The type of the principal genus of this group has not yet been anatomically examined, but species of two apparently closely related sections, *Monostiolum* and *Maculotriton*, have been examined by the writer and by Messrs. Pilsbry and Vanatta,[1] and prove rhachiglossate. Since the history of both groups is practically intertwined from the time of their first recognition, both are included here, as well as in the synonymic history with which this article concludes.

Family COLUBRARIIDÆ

Genus COLUBRARIA Schumacher, 1817

Type *Buccinum maculosum* Chemnitz. Recent. Synonyms: *Colubraria* Schumacher, Fischer, Harris, Dall, Cossmann, not Jousseaume, 1881; + *Epidromus* Mörch, 1852, H. and A. Adams, 1853; + *Cumia* Bivona, 1838.

Hilda Hoernes, 1884, from the Miocene, has been referred to this group as a subgenus by Fischer, but is regarded as a full genus by Cossmann, from whose figures I should be inclined to regard it as a precursor and near relative of *Lampusia* with only a terminal varix. I have not seen specimens and therefore hesitate to assign it a definite systematic rank, but feel quite sure it should not be united with *Colubraria*, notwithstanding part of the latter genus is restricted to a single varix.

The genus *Colubraria* is naturally divisible into several sections or groups.

Section *Colubraria* s. s.

Type *Murex maculosus* Gmelin, 1792. India.

Solid, heavy shells with elevated spire, appressed sutures, numerous irregularly disposed prominent rib-like varices, a short recurved

[1] The paper by Mr. Pilsbry in which he suggests that *Colubraria* may prove rhachiglossate and notes that he and Mr. Vanatta had found *Triton bracteatus* Hinds and *T. decapitatus* Reeve to be so, was received by me only after this paper had been sent to the printer, and it gives me much pleasure to confirm his surmise as far as that may be done by a determination of the rhachiglossate character of "*Epidromus*" *swifti* Tryon.

canal, prominent heavy body-callus, feebly sculptured or smooth, the callus reflected over the pillar and body whorl, the margin of the columellar reflection free and entire, the outer lip denticulate. The nuclear whorls conical but very small. Operculum "triangular with submarginal nucleus" *fide* Tryon. Sculpture nodulose-reticular.

The varices in this group are so swollen that the following whorl is apt to become oblique on the axis and the whole spire is often tortuous. Coloration nebulous, yellow, brown and white.

?Subgenus CUMIA Bivona, 1838.

Type *C. decussata* Bivona, = *Triton reticulatus* Blainville, Mediterranean.

Shell small, delicate, spire not torticular; protoconch minute, smooth, lying on a planorboid nepionic shell with deep sutures and rounded whorls. Operculum elongate-ovate with apical nucleus. Varices numerous, irregular. Colors as in *Colubraria* s. s.

Section *Maculotriton* Dall, nov.

Type *Triton bracteatus* Hinds, Polynesia.

Shell ribbed axially and sulcate spirally; apex obtuse, spire elevated, with appressed sutures, varices inconspicuous, two or three only. Nucleus of two or three whorls; coloration of black and white, usually conspicuously articulated; operculum?

Section *Monostiolum* Dall, nov.

Type *Triton swifti* Tryon, West Indies.

Shell small, with elevated spire and a single terminal varix; nucleus with the protoconch immersed in the first nepionic whorl leaving an apical pit; next later whorls axially ribbed, the ribs obsolete on the subsequent whorls of the adult; coloration as in *Colubraria* s. s.; sutures appressed; operculum elongate-oval, with apical nucleus. Animal with slender tentacles, the eyes prominent on their outer bases; the verge sickle-shaped and recurved on the back of the neck; the radula long, carrying teeth of a type closely similar to those of *Pisania maculosa* Lamarck, and *P. fusiformis* Blainville, as figured by Troschel, and with the dental formula $\frac{1}{3} \cdot \frac{1}{3} \cdot \frac{1}{3}$, the base of the rhachidian tooth not excavated in front.

Section *Caducifer* Dall, nov.

Type *Triton truncatus* Hinds, Polynesia.

Shell small, subcylindric, the upper fourth of the spire self-amputated in the adult; a single terminal varix; sculpture of axial ribs and spiral threading, sutures appressed. Nucleus? Operculum?

There is a considerable Polynesian group of these normally decollated species.

Section *Tæniola* Dall, nov.

Type *Triton decollatus* Sowerby, Polynesia.

Shell small, subconical, the nepionic shell normally decollate; first subsequent whorl or two with faint axial ribs, the remainder with only sharp deep sulci between strap-like smooth spiral ribs; a single prominent and terminal varix; suture appressed, coloration in continuous spiral lineation. Operculum?

The sculpture of this and one other form is in such sharp contrast to that of the other species of the genus that it seems as if it is entitled to a sectional distinction.

Subgenus Phrygiomurex Dall, nov.

Type *Triton sculptilis* Reeve, Polynesia.

Shell small, frequently truncate at the apex, nucleus smooth, visible part subconic or turbinate, test fusiform, not torticular, with subacute spire and short recurved canal; whorls axially ribbed, the posterior ends of the ribs coronating the suture, the interspaces filled with thin crisp axial lamellæ closely crowded, crossed by spiral threads and forming a sort of superficial lace-like coating to the shell, recalling that of *Scala cochlea* Sowerby, or unworn *Aspella;* varices irregularly disposed, callus of the aperture not conspicuous, operculum narrow, muricoid, the nucleus mid-lateral. Color whitish.

The type species has a deep spiral sulcus on the base, bordered by two strong revolving ribs and crossed by the anterior ends of the ribs, thus forming conspicuous pits; there are from one to three varices, chiefly on the last whorl. In *Triton antiquatus* Hinds, which seems to belong to the same group, the shell is more cylindric, the ribs fainter, the anterior sulcus wanting, and the varices occur on any part of the spire; but are nowhere very prominent.

This group has so many conchological characters in common with the tritons that one hesitates to separate them, but the peculiar surface recalls *Aspella* and the operculum is unlike any other among the true Tritons which I have seen. I am inclined to believe that this section will eventually find a place among the true Trophons or near some of the Purpuroid Murices.

It is noticeable that the canal is never closed in the *Septidæ,* and any shell, no matter how superficially similar, with a closed canal may confidently be referred to the *Muricidæ.* But in the cases such as this where the canal is not closed the final allocation must depend upon the characters of the radula.

I close this review with a list of references giving the synonymic history of the *Septidæ* so far as binomial authors are concerned.

SYNONYMIC HISTORY OF THE SUBDIVISIONS OF THE FAMILY SEPTIDÆ

Murex (sp.) LINNÉ, Syst. Nat. ed. x, pp. 748–749, 1758; ed. XII, p. 1213 et seq., 1767.

Tritonium BOLTEN, Mus. Bolt. p. 125, 1798; ed. II, p. 88, 1819; not of O. F. MÜLLER, 1776.

Cymatium BOLTEN, *op. cit.*, p. 129, 1798; first species *Murex femorale* LINNÉ; ed. II, p. 91, 1819.

Cabestana BOLTEN, *op. cit.*, p. 130, 1798; first species *Murex cutaceus* LINNÉ; ed. II, p. 92, 1819.

Distorsio (pars) BOLTEN, *op. cit.*, p. 133, 1798; *Murex anus* LINNÉ; ed. II, p. 94, 1819.

Tritonium (sp.) LINK, Beschr. Rostock Samml., p. 121, 1807.

Distortrix LINK, *op. cit.*, p. 122, 1807; *Murex anus* LINNÉ.

Gyrineum (pars) LINK, op. cit., p. 123, 1807; *Murex gyrinus* L.

Apollon MONTFORT, Conch. Syst., II, p. 571, 1810; *Murex gyrinus* LINNÉ (= *Gyrineum* LINK, *ex parte*).

Aquillus MONTFORT, Conch. Syst., II, p. 578, 1810; *Murex cutaceus* LINNÉ (= *Cabestana* BOLTEN).

Lotorium MONTFORT, Conch. Syst., II, p. 582, 1810; *Murex femorale* LINNÉ (= *Cymatium* BOLTEN *non* Link).

Triton MONTFORT, Conch. Syst., II, p. 586, 1810; *T. australe* var. β REEVE (= *Tritonium* BOLTEN, not of Müller). Not *Triton* LINNÉ, 1768.

Persona MONTFORT, Conch. Syst., II, p. 602, *Murex anus* LINNÉ (= *Distortrix* LINK); Gray, Guide Moll. Brit. Mus., p. 43, 1857.

Monoplex (*pars*) PERRY, Conch., expl. pl. III, 1811. No type selected, but Gray, 1847, selects *T. olearium* (L.) REEVE, = *Monoplex australasiæ* PERRY, fig. 3, = *M. costatus* BORN.

Biplex (sp.) PERRY, Conch., expl. pl. IV, 1811, *B. perca* PERRY, selected as type by Gray, 1847.

Septa PERRY, Conch., expl. pl. XIV, 1811. Contains species of *Cymatium* (BOLTEN) and *Triton nodiferus* LAM.

Lotorium (sp.) CUVIER, Règne Anim., II, p. 440, 1817, *M. lotorium* LINNÉ.

Tritonium CUVIER, Règne Anim., II, p. 440, 1817, *M. tritonis* LINNÉ.

Apollon (MONTFORT) CUVIER, *op. cit.*, p. 441, *M. gyrinus* LINNÉ.

Distorta SCHUMACHER, Essai, pp. 76, 249, 1817 (= *Distortrix* LINK).

Lampusia α SCHUMACHER, Essai, pp. 76, 250, 1817, *Murex pileare* LINNÉ (= *Cymatium* BOLTEN, sp.).

Lampusia β SCHUMACHER, *op. cit.*, *Murex tritonis* LINNÉ (= *Septa* PERRY, sp.).

Colubraria SCHUMACHER, *op. cit.*, pp. 76, 251, *Buccinum maculosum* CHEMNITZ.

Lampas SCHUMACHER, *op. cit.*, pp. 76, 252, *Murex lampas* LINNÉ, = *Bufonaria* β SCHUMACHER (*Ranellidæ*). Not *Lampas* Mus. Calonnianum, 1797.

Cassida DILLWYN, Descr. Rec. Sh., II, p. 703, 1817, in syn. *Murex anus* LINNÉ (= *Distortrix* LINK). Not *Cassida* LINNÉ, Coleopt. 1758.

Varicaria O. FABRICIUS, Fortegnelse over afg. Biskop Fabricius efterl. naturalier. Hafniæ, 1823, p. 87. Nude name followed by nude specific names, apparently covering *Tritonium* + *Ranella, senso lato.*

Gyrina SCHUMACHER, Essai, pp. 77, 253, 1817, *Ranella gigantea* LAM. Not *Gyrinus* LINNÉ, 1768.

Ranula SCHUMACHER, Essai, p. 77, 1817, not of Peters, 1859.

Ranularia SCHUMACHER, *op. cit.*, p. 253, *Triton clavator* LAM. (= *Ranula* SCHUM. + *Monoplex* [sp.] PERRY.)

Triton LAMARCK, Anim. s. Vert., VII, p. 177, 1822, *ex parte*, = *Tritonium* BOLTEN, Cuvier.

Tritonium BOWDICH, Elem. Conch. I, p. 36, 1822, not of Müller, 1776, and

Tritonia BOWDICH, *op. cit.*, expl. pl. X, fig. 4, 1822, not of Cuvier, 1798, = *Triton* MONTFORT, = *Septa* (*pars*) PERRY.

Triton (*pars*) BLAINVILLE, Man. Mal., I, p. 399, 1825; Sowerby, Genera, part XXX, 1828; FLEMING, Brit. An., pp. 346, 356, 1828; SWAINSON, Malac., p. 297, 1840; SOWERBY, Conch.. Man. ed. II, p. 278, 1842.

Dolarium SCHLEUTER, Verzeichn., p. 20, 1838, sole ex. *Murex caduceus* LINNÉ (*ubi*?).

Currus LESSON, l'Echo du Monde Sav. IIme Ser. VI, col. 65, July 14, 1842, *Triton tigrinus* Brod. (= *Cymatium* BOLTEN).

Cumia BIVONA, Car. Nuovo Gen. Conch., 1838; *C. decussata* BIV., = *Ranella lanceolata* MENKE; *fide* Philippi, Moll. Siciliæ, II, p. 183, 1844 (= *Colubraria* SCHUMACHER).

Luterium HERRMANNSEN, Ind. Gen. Mal., I, p. 625, 1846; new name for *Lotorium* MONTFORT (= *Cymatium* BOLTEN).

Charonia GISTEL, Naturg. Thierr., p. 170, 1848; new name for *Tritonium* CUVIER *non* Müller (= *Septa* PERRY, 1811).

Nyctilochus GISTEL, Naturg. Thierr., p. XI, 1848; new name for *Triton* MONTFORT *non* Laurenti (= *Septa* PERRY, 1811).

Argobuccinum MÖRCH, Yoldi Cat., p. 105, 1852; first species *Ranella vexillum* BRODERIP.

Apollon MÖRCH, Yoldi Cat., p. 106, 1852; heterogeneous assembly.

Distorsio MÖRCH, Yoldi Cat., p. 107, 1852; *Murex anus* LINNÉ.

Epidromus MÖRCH, Yoldi Cat., p. 107, 1852 (= *Colubraria* SCHUM.).

Aquilus MÖRCH, Yoldi Cat., p. 108, 1852 (= *Cabestana* BOLTEN).

Lampusia MÖRCH, Yoldi Cat., p. 108, 1852 (= *Triton* MONTFORT).

Simpulum MÖRCH, Yoldi Cat., p. 108, 1852; *Triton pileare* LAM. (= *Cymatium* BOLTEN, sp.).

Cymatium MÖRCH, Yoldi Cat., p. 109, 1852 (= *Lotorium* MONTFORT).

Gutturnium MÖRCH, Yoldi Cat., p. 109, 1852; *Triton tuberosum* LAMARCK.

Ranularia MÖRCH, Yoldi Cat., p. 109, 1852; *Triton clavator* LAM., after Chemnitz.

Monoplex MÖRCH, Yoldi Cat., p. 110, 1852, *M. obesus* PERRY, = *Triton retusum* LAM.

Lagena MÖRCH, Yoldi Cat., p. 110, 1852, *Triton clandestinum* LAMARCK.

Tritonium H. and A. ADAMS, Gen. Rec. Moll., I, p. 101, 1853; *T. tritonis* (LINNÉ) = *Septa* PERRY.

Simpulum H. and A. ADAMS, *op. cit.*, p. 102, 1853 (not of Fabricius, 1823), no type cited, but the genus is ascribed to Klein, whose figured example is *Triton olearium* LAMARCK (= *Monoplex* PERRY) = *costatus* BORN.

Cabestana H. and A. ADAMS, *op. cit.*, p. 102, 1853, after Bolten, whose type was *Murex cutaceus* LINNÉ.

Cymatium H. and A. ADAMS, *op. cit.*, p. 102, 1853; *Murex femorale* LINNÉ.

Gutturnium H. and A. ADAMS, as of Klein, *op. cit.*, p. 103, 1853; Klein's figured example is *Triton tuberosum* LAMARCK.

Epidromus H. and A. ADAMS, as of Klein, *op. cit.*, p. 103, 1853 (= *Colubraria* SCHUMACHER).

Lagena H. and A. ADAMS, as of Klein, *op. cit.*, p. 104, 1853; not of Walker, 1784. Klein's figured example is *Triton clandestinum* LAM.

Argobuccinum H. and A. ADAMS, *op. cit.*, p. 104, 1853; *Triton rude* BRODERIP, and *scaber* KING; not *Argobuccinum* of Klein; corrected by Adams in the errata.

Distorsio H. and A. ADAMS, *op. cit.*, as of Bolten, p. 104, 1853, *Murex anus* LINNÉ (= *Distortrix* LINK).

Distortio H. and A. ADAMS, *op. cit.*, *in index, err. typ. pro Distorsio.*

Neptunella GRAY, P.Z.S. 1853, p. 38. *Murex cutaceus* LINNÉ, sole example (= *Cabestana* BOLTEN).

Linatella GRAY, Guide Moll. Brit. Mus., p. 39, 1857; *Triton cingulatum* LAM., sole example. Not *Linatella* H. and A. ADAMS, 1858, in synonymy.

Apollon H. and A. ADAMS, I, p. 106, 1853, not of Montfort, 1810; Gray, Guide Moll. Brit. Mus., p. 42, first species *A. vexillum* BRODERIP.

Priene H. and A. ADAMS, II, p. 654, 1858, *Triton rude* BRODERIP, and *T. scaber* KING. This is a new name for *Argobuccinum* ADAMS, 1853, not of Klein.

Argobuccinum H. and A. ADAMS, Gen. Rec. Moll., II, p. 655, 1858, as of Klein, whose figured example is *Murex argus* GMELIN. Not *Argobuccinum* H. and A. ADAMS, I, p. 104, 1853, but a new name for *Apollon* H. and A. ADAMS, 1853, p. 106.

Neptunella H. and A. ADAMS, Gen. Rec. Moll., II, p. 654, 1858; in errata (= *Cabestana* BOLTEN).

Tritonium (Link) TROSCHEL, Gebiss der Schnecken, I, p. 232, 1863; *Murex Tritonis* LINNÉ.

Distorsio (Bolten) TROSCHEL, Gebiss der Schnecken, I, p. 233, 1863; *Murex anus* LINNÉ (= *Distortrix* LINK).

Cymatium (Bolten) TROSCHEL, Gebiss der Schnecken, I, p. 233, 1863; *Murex femorale* LINNÉ.

Simpulum TROSCHEL, *Gebiss der Schnecken*, I, p. 234, 1863; *Murex pileare* LINNÉ, first species. Not *Simpulum* FABRICIUS, 1823.

Gutturnium TROSCHEL, Gebiss der Schnecken, I, p. 235, 1863; *Triton tuberosum* LAM., first species.

Cabestana (BOLTEN) TROSCHEL, Gebiss der Schnecken, I, p. 237, 1863; *Triton cutaceum* LAM.

Apollon TROSCHEL, Gebiss der Schnecken, I, p. 237, 1863; *Murex argus* GMELIN (= *Argobuccinum* ADAMS).

?*Trachytriton* MEEK, S. I. checkl. Cretaceous fos. N. Am., pp. 22, 27, 1864; *T. vinculum* HALL and MEEK, St. Pierre beds of Dakota (a precursor of *Priene?*); Paleontol. Upper Missouri, p. 303, 1876.

Distortio CONRAD, Am. Journ. Conch., I, p. 20, 1865; *D. crassidens* CONRAD, Oligocene of Vicksburg (= *Distortrix* LINK).

Personella CONRAD, Am. Journ. Conch., I, p. 21, 1865. Type *Distorsio septemdentata* GABB, Eocene of Texas.

Ranellina (as *Sanellina* by typ. error) CONRAD, Am. Journ. Conch., I, p. 21, 1865; type *Ranella Maclurii* CONRAD, Claibornian Eocene; Conrad, S. I. checkl. Inv. fos. N. Am., Eocene, p. 17, 1866.

Simplum STOLICZKA, Cret. Gastr. India, p. 131, 1867. Apparently a lapsus for *Simpulum* H. and A. ADAMS.

Sassia BELLARDI, Moll. Terz. Piemont e Liguria, pt. I, p. 249, 1873; type *Triton apenninicum* SASSI, Miocene of Italy (= ? *Personella* CONRAD).

Apollon MÖRCH, Mal. Blatt., XXIV, p. 24, 1877 (= *Apollon* MONTFORT).

Gyrinea MÖRCH, Mal. Blatt., XXIV, p. 24, 1877, in synonymy, not *Gyrina* SCHUMACHER, 1817; *Biplex corrugata* PERRY.

Triton MÖRCH, Mal. Blatt., XXIV, p. 25, 1877, = *Triton* LAMARCK.

Tritonellium MÖRCH, Mal. Blatt., XXIV, p. 25, 1877, in synonymy, = *Triton* LAMARCK; not *Tritonellium* VALENCIENNES, 1858, = *Tritonium* MÜLLER not Bolten.

Trompeta MÖRCH, Mal. Blatt., XXIV, p. 25, 1877, in synonymy as of Petiver, = *Triton* LAMARCK.

Buccinatorium MÖRCH, Mal. Blatt., XXIV, p. 26, 1877, as of Petiver; *Triton variegatum* CONRAD (= *Septa pars,* PERRY).

Charonis MÖRCH, Mal. Blatt., XXIV, p. 26, 1877 (*err. typ. pro Charonia* GISTEL).

Lampusia MÖRCH, Mal. Blatt., XXIV, p. 27, 1877, *Murex pileare* LINNÉ (= *Lampusia* α SCHUMACHER).

Cymatium MÖRCH, Mal. Blatt., XXIV, p. 31, 1877, *Triton femorale* LAM. (= *Lotorium* MONTFORT).

Gutturnium MÖRCH, Mal. Blatt., XXIV, p. 31, 1877,*Triton tuberosum* LAMARCK.

Linatella MÖRCH, Mal. Blatt., XXIV, p. 32, 1877 (= *Linatella* GRAY).

Cabestana MÖRCH, Mal. Blatt., XXIV, p. 33, 1877 (= *Cabestana* BOLTEN).

Dolarium (Schleuter) MÖRCH, Mal. Blatt., XXIV, p. 33, in synonymy, = *Cabestana* BOLTEN, *fide* Mörch.

Distorsio MÖRCH, Mal. Blatt., XXIV, p. 34, 1877 (= *Distortrix* LINK).

Semiranella DE GREGORIO, Studi Conch. Med. viv. et fos., 1880. Type *Triton gemmellari* DE GREG. (= *Sassia* BELLARDI, 1871, *fide* Cossmann, 1903). Eocene.

Hilda HOERNES et AUINGER, Abh. K. K. Geol. Reichsanst., XII, 1884, p. 182, pl. XXII, figs. 17–20; *Triton transylvanicus* H. and A., Miocene (= *Colubraria* subg.); not *Hilda* Kirkaldy, *Insecta,* 1900.

Triton FISCHER, Man. de Conch., p. 654, 1884; *T. tritonis* LINNÉ (= *Tritonium* CUVIER), sect. *Triton* s. s. = *Septa* (Perry) DALL.

Colubraria FISCHER (section of *Triton*), *op. cit.,* p. 654, 1884; *T. maculosus* MARTINI (= *Colubraria* SCHUM.).

Plesiotriton FISCHER (section of *Triton*), *op. cit.,* p. 654, 1884; *Cancellaria volutella* LAMARCK.

Hilda FISCHER (section of *Triton*), *op. cit.,* p. 655, 1884; *Triton transylvanicus* HOERNES.

Simpulum FISCHER (subgenus of *Triton*), *op. cit.,* p. 655, 1884; *T. pileare* (L.).

Aquillus FISCHER (section of *Simpulum*), *op. cit.,* p. 655, 1884; *T. cutaceus* (L.), = *Cabestana* BOLTEN.

Lotorium FISCHER (section of *Simpulum*), *op. cit.,* p. 655, 1884; *T. femoralis* (L.), = *Cymatium* BOLTEN.

Sassia FISCHER (section of *Simpulum*), *op. cit.,* p. 655, 1884; *T. apenninicus* SASSI (= *Personella* CONRAD).

Linatella FISCHER (section of *Simpulum*), *op. cit.*, p. 655, 1884; *T. poulseni* MÖRCH.

Priene FISCHER (section of *Simpulum*), *op. cit.*, p. 655, 1884; *T. scaber* KING (?= *Priene* H. and A. ADAMS).

Ranularia FISCHER (subgenus of *Triton*), *op. cit.*, p. 655, 1884; *T. cynocephalus* LAMARCK. Not *Ranularia* SCHUMACHER.

Trachytriton FISCHER (subgenus of *Triton*), *op. cit.*, p. 655, 1884 (= *Trachytriton* MEEK, 1864).

Argobuccinum FISCHER (subgenus of *Triton*), *op. cit.*, p. 655, 1884; *Murex argus* GMELIN.

Gyrina FISCHER (section of *Argobuccinum*), *op. cit.*, p. 655, 1884; *Ranella gigantea* LAMARCK.

Apollo FISCHER (section of *Argobuccinum*), *op. cit.*, p. 655, 1884; *Murex gyrinus* LINNÉ (= *Apollon* MONTFORT).

Biplex FISCHER (section of *Argobuccinum*), *op. cit.*, p. 655, 1884; *Ranella pulchra* GRAY (= *Biplex* PERRY, *ex parte*).

Persona FISCHER, *op. cit.*, p. 655, 1884; *Murex anus* LINNÉ (= *Distortrix* LINK).

Monocirsus COSSMANN, Catal. Illustré Eoc. de Paris, IV, p. 116, 1889; *Triton carinulatus* COSSMANN. Eocene.

?*Murotriton* DE GREGORIO, Mon. Eoc. Ala., p. 97, 1890; sole ex. *Triton grassator* DE GREG. Recent? Fossil? Habitat? Horizon? (not stated) but from the figures may = *Eupleura* STM., 1865, of the *Muricidæ*.

Lampusia NEWTON, Brit. Olig. Eoc. Moll., p. 145, 1891 (= *Tritonium* LINK *non* Müller. The family name *Lampusiidæ* is proposed in place of *Tritonidæ*).

Lotorium HARRIS, Cat. Tert. Moll. Brit. Mus., I, p. 185, 1897, *Murex lotorium* LINNÉ (= *Triton* MONTFORT + *Lampusia* SCHUM.). The family *Lotoriidæ* is proposed.

Colubraria HARRIS, *op. cit.*, p. 194, 1897, *C. granulata* SCHUM. (= *Colubraria* SCHUM.).

Apollo HARRIS, *op. cit.*, p. 195, 1897. *Murex gyrinus* L. (= *Apollon* MONTFORT).

Tritonium ROVERETO, Atti Soc. Ligustica, X (extr. p. 6), 1899 (= *Triton* LAM.).

Distortrix DALL, Moll. Porto Rico, p. 416, 1901, *D. reticulata* LINK (= *Distortrix* LINK).

Gyrineum DALL, Moll. Porto Rico, p. 416, 1901 (= *Gyrineum* LINK).

Septa DALL, Moll. Porto Rico, p. 416, 1901, *Septa tritonis* L. (= *Septa* PERRY, restricted + *Triton* MONTFORT *non* Linné. The family *Septidæ* is proposed for *Tritonidæ* AUCT.); *Nautilus*, XVII, p. 55, Sept., 1903.

Colubraria DALL, Moll. Porto Rico, p. 416, 1901, *C. lanceolata* MENKE (= *Colubraria* SCHUMACHER).

Ranularia DALL, Moll. Porto Rico, p. 417, 1901, *R. tuberosa* (LAM.) = *Gutturnium* MÖRCH.

Lampusia DALL, Moll. Porto Rico, p. 417, 1901, *Triton pileare* LAM. (= *Lampusia* a SCHUM.).

Lotorium DALL, Moll. Porto Rico, p. 417, 1901, *Murex femorale* LINNÉ (= *Lotorium* MONTFORT).

Lotorium KESTEVEN, Proc. Linn. Soc. N. S. Wales, XXVII, No. 107, pp. 443–483, Dec., 1902 (= *Triton* LAMARCK *senso lato*). The family name of *Lotoriidæ* is accepted

Tritonium COSSMANN, Essais de Pal. Comp., V., pp. 87, 90, 1903; *Murex tritonis* L. (= *Septa* PERRY, restr. This is not one of the "cassides" of the Museum Geversianum as erroneously stated by Rovereto. The name *Cassida* does not appear in that work, which was prepared by Meuschen).

Lampusia COSSMANN, op. cit., pp. 87, 92, 1903. Type *Murex pileare* LINNÉ. Subgenus of *Tritonium* COSSMANN (= *Cymatium* BOLTEN *pars*).

Sassia COSSMANN, *op. cit.*, pp. 87, 93, 1903. Section of *Lampusia* COSSMANN. Type *Triton apenninicum* SASSI.

Aquillus COSSMANN, *op. cit.*, pp. 87, 93, 1903. Section of *Lampusia* COSSMANN. Type *Murex cutaceus* LINNÉ (= *Cabestana* BOLTEN).

Ranularia COSSMANN, *op. cit.*, pp. 87, 97, 1903. Subgenus of *Tritonium* COSSMANN. Type *Triton clavator* LAMARCK (= *Ranula* + *Ranularia* SCHUMACHER).

Austrotriton COSSMANN, *op. cit.*, pp. 87, 98, 1903. Subgenus of *Tritonium* COSSMANN. Type *Triton radialis* TATE.

Zinatella COSSMANN, *op. cit.*, p. 87, 1903. Section of *Lotorium* COSSMANN (= *Linatella* GRAY, Cossmann, l. c., p. 88, *type T. poulseni* MÖRCH).

Colubraria COSSMANN, *op. cit.*, p. 99, 1903; subgenus of *Tritonium* COSSMANN, type *Murex maculosus* GMELIN.

Plesiotriton COSSMANN, *op. cit.*, pp. 87, 101, 1903, type *Cancellaria volutella* LAMARCK (= *Plesiotriton* FISCHER).

Semitriton COSSMANN, *op. cit.*, pp. 87, 102, 1903, type *Triton Dennanti* TATE, Eocene, S. Australia.

Persona COSSMANN, *op. cit.*, pp. 87, 103, 1903, type *Murex anus* LINNÉ (Syn. excl. = *Distortrix* LINK).

Hilda COSSMANN, *op. cit.*, pp. 87, 106, 1903, type *H. transylvanica* HOERNES, Miocene.

Monocirsus COSSMANN, *op. cit.*, pp. 87, 108, 1903, type *Triton carinulatus* COSSMANN, Eocene; subgenus of *Hilda*.

Priene COSSMANN, *op. cit.*, pp. 87, 109, 1903, type *Triton scaber* KING (= *Priene* H. and A. ADAMS).

Trachytriton COSSMANN, *op. cit.*, pp. 87, 110, 1903 (= *Trachytriton* MEEK). Retained as a subgenus of *Priene*.

Fusitriton COSSMANN, *op. cit.*, pp. 87, 109, 1903, as subgenus of *Priene*. Type *Triton cancellatus* LAM.

Ranella COSSMANN, *op. cit.*, pp. 88, 111, 1903. Type *Ranella gigantea* LAM. (= *Gyrina* SCHUMACHER).

Biplex COSSMANN, *op. cit.*, p. 88, 1903; type *Ranella pulchra* GRAY (= *Biplex* PERRY, restr.); as section of *Ranella*.

Argobuccinum COSSMANN, *op. cit.*, pp. 88, 114, 1903, as subgenus of *Ranella*, type *Murex argus* GMELIN (= *Argobuccinum* Klein) ADAMS, 1858, not ADAMS, 1853.

Aquillus PILSBRY, Proc. Acad. Nat. Sci. Phila., 1904, p. 22. Type *M. cutaceus* LINNÉ (= *Cabestana* BOLTEN). Typical genus of proposed family *Aquillidæ*, including the following groups.

Lampusia PILSBRY, *loc. cit.*, section of *Aquillus*, type *M. pilearis* Linné (= *Cymatium pars*, BOLTEN).

Lotorium PILSBRY, *loc. cit.*, section of *Aquillus*, type *M. femorale* LINNÉ (= *Cymatium* BOLTEN *non* Link).

Monoplex PILSBRY, *loc. cit.*, section of *Aquillus*, type *M. cynocephalus* LINNÉ (= *Tritonocauda* DALL).

Septa PILSBRY, *loc. cit.*, subgenus of *Aquillus*, type *S. rubicunda* PERRY.

Distortrix PILSBRY, *loc. cit.* (= *Distortrix* LINK).

Priene PILSBRY, *loc. cit.* as of H. and A. ADAMS.

Colubraria PILSBRY, *loc. cit.*, type *M. maculosa* GMELIN (= *Colubraria* SCHUMACHER).

Cumia PILSBRY, *loc. cit.*, subgenus of *Colubraria* (= *Cumia* BIVONA).

Apollon PILSBRY, *loc. cit.* (= *Gyrineum* LINK, *pars*).

Gyrineum PILSBRY, *loc. cit.* (= *Ranella* LAMARCK).

NAPLES ZOOLOGICAL STATION. PRESENT BUILDINGS

THE SMITHSONIAN TABLE AT THE NAPLES ZOOLOGICAL STATION

By HELEN WALDO BURNSIDE

In the winter of 1893 a memorial was addressed to the Smithsonian Institution asking that it become responsible for the support of a table for original research in the Naples Zoölogical Station. This memorial, signed by nearly two hundred working biologists, who represented approximately eighty universities, colleges, and scientific institutions in the United States, received due consideration and in April, 1893, Secretary Langley announced that it had been decided to procure a table at the Station on behalf of the Institution for three years.

Desiring to acquaint himself with the views of representative biologists in regard to the best administration of the table, the Secretary recommended the formation of an advisory committee of four persons, one each to be nominated by four of the prominent scientific societies of the country. In accordance with this suggestion, Doctor J. S. Billings, U. S. A., was named by the President of the National Academy of Sciences, Professor E. B. Wilson of Columbia University, New York, on behalf of the Society of American Naturalists, Doctor C. W. Stiles of the U. S. Department of Agriculture on behalf of the American Morphological Society, and Professor John A. Ryder of the University of Pennsylvania to represent the Association of American Anatomists. These nominations were ratified, Doctor Billings being designated by the Secretary of the Institution as chairman of the committee, and Doctor Stiles as secretary. The Committee as thus constituted remained unchanged until the appointment in May, 1895, of Doctor Harrison Allen to the vacancy caused by the death of Doctor Ryder; and in January, 1898, the appointment of Doctor Theodore Gill, with Doctor G. S. Huntington as alternate, to the place made vacant by the death of Doctor Allen. During the same year Doctor Albert Hassall, of the U. S. Department of Agriculture, was accepted as the representative of Doctor Stiles, during the absence of the latter in Europe, and Doctor T. H. Morgan of Bryn Mawr has twice served in the place of Doctor Wilson during similar absences. During its entire tenure of the table the Smithsonian has therefore had the valuable aid of substantially the same committee in the examination of testimonials and in recommending action with regard to applications for the seat.

The fact that a table in the Naples Zoölogical Station had been obtained by the Smithsonian Institution and placed at the service of American students was at once announced, the main condition of appointment being that with an application for the seat a candidate should submit credentials as to his capability for carrying on original investigations in some field for which especial facilities are offered at the Station. Candidates for the seat were invited to submit an outline of their scientific history, mentioning the degrees received and the original papers published by them. They were also permitted to submit any letters of recommendation they might wish to have placed on record, a summary of such data being forwarded to Doctor Dohrn, the Director of the Station, with each notice of an approved appointment. Although many of the leading biologists of the country, whose services as such are widely known, have occupied the table, these conditions, necessarily established in the interest of a general candidacy, have been courteously complied with.

While a circumstantial report of the work accomplished at Naples has never been required, those whose applications are approved are requested to notify the Secretary at the close of a session, and at the same time to present a brief outline of their investigations. In this way the Institution is able to keep in touch not only with the work of its special appointees, but also to obtain an interesting insight into the admirable methods employed at the Station for the accommodation of investigators. A summary of the data thus submitted has appeared at intervals in the Smithsonian publications, the action of the Institution in this connection being designed to interfere in no way with the plans of the author as to publication elsewhere.

Applications for the Smithsonian seat have been numerous, to such an extent, in fact, that although the collective appointments for any year have but twice exceeded an occupancy of twelve months for one student, not infrequently two, and in rare instances three occupants have been accommodated at the same time on behalf of the Institution, through the kindness of Doctor Dohrn, who has in several instances exceeded any favor requested at his hands. The courtesy thus extended to the Smithsonian and its appointees has frequently proved an advantage to students who have been prevented by unexpected changes in their engagements at other establishments from reaching Naples at the date fixed for their reception, and who would otherwise have been deprived of a part of the period allotted to them. The irregularity with which applications for the Smithsonian seat are received also tends to create complication as to occupancy, but at the same time this condition offers a partial compensation for the crowding at intervals from the fact that there is occasionally a period of some length without an appointee at the Smithsonian table, which is then at the service of the Director for such students as it may suit his convenience to receive. The average annual occupancy of the Smithsonian table for the first eleven years of its existence, 1893 to 1904, may be stated in general terms as eight and one-half months.

Before the expiration of the first term of three years for which the Institution became responsible for the support of a table in the Zoölogical Station, a second memorial was received urging the renewal of the lease. This petition, like the first, was signed by many representative biologists and officials of scientific institutions, some of whom emphasized the advantage to American students of having one American table at Naples which was not affiliated with any college but rather under the unattached administration of the Smithsonian Institution. Since the renewal of the lease of the table for a second term of three years, it has twice been extended for shorter periods, and the seat has now been obtained on behalf of the Institution for three years from January 1st, 1904.

During the twelve years for which the Smithsonian has been responsible for the support of a table, an annual average of three applications has been approved on behalf of nearly forty naturalists, some of whom have filled more than one appointment. These investigators were connected with schools, colleges, and universities in widely different localities, thus representing, it may be said, nearly the whole breadth of the United States, as shown by the following list of educational institutions whose alumni or professors have occupied the Smithsonian seat:

Adelbert College, Cleveland, Ohio.
Arkansas Industrial University, Fayetteville.
Brown University, Providence, R. I.
University of California, Berkeley.
University of Chicago, Chicago.
Clark University, Worcester, Mass.
Coe College, Cedar Rapids, Iowa.
Columbia University, New York City.
Cornell University, Ithaca, N. Y.
Dartmouth College, Hanover, N. H.
Eureka College, Eureka, Illinois.
German American Normal College, Milwaukee, Wis.

Harvard University, Cambridge, Mass.
Hobart College, Geneva, N. Y.
Indiana University, Bloomington.
Iowa Agricultural College, Ames.
Johns Hopkins University, Baltimore, Md.
Kansas Agricultural College, Manhattan.
Kentucky State College, Lexington.
Leland Stanford Jr. University, Cal.
Michigan State Agricultural College, Ingham county, Michigan.
University of Michigan, Ann Arbor.
University of North Carolina, Chapel Hill.
Olivet College, Olivet, Michigan.
Rutgers College, New Brunswick, N. J.
Syracuse University, Syracuse, N. Y.
Ursinus College, Collegeville, Pennsylvania.
Wesleyan University, Middletown, Connecticut.
West Virginia University, Morgantown.
Yale University, New Haven, Conn.

The individual periods of occupancy of the Smithsonian table have varied in length from a month to six months, it having been decided in the interest of all who desire the seat that no appointment should be approved for longer than the latter term, although in exceptional cases an extension may be asked for and granted, if such action does not interfere with the occupancy of other applicants.

In order to give all prospective appointees equal opportunities to avail themselves of the advantages of the table, the Smithsonian seat is not assigned more than six months in advance of the date for which it is desired; it has therefore been requested that applications be submitted at the time when it is in order to take them up for consideration. Should more than one request be filed for the same period, appointment is made according to priority of application, within the specified six months.

An application for a seat accompanied with historical data and recommendatory letters is referred to the Advisory Committee for consideration and report, and on this report the Secretary of the Institution bases his action. In case of approval, the Director of the Station is notified and a summary of the appointee's scientific history is transmitted to him, so that each investigator finds himself introduced in advance to Doctor Dohrn and his assistants.

Of the four tables now subscribed for by scientific bodies in the United States, two are maintained by the Carnegie Institution and

VIEW OF INTERIOR OF NAPLES ZOOLOGICAL STATION, SHOWING INDIVIDUAL LABORATORIES

one by the Smithsonian, the fourth being the Women's Table, the use of which when unoccupied has been courteously offered to the Institution for the not infrequent periods when the Smithsonian applicants are too numerous to be accommodated at one table.

It may be added that Germany supports eleven tables, Italy nine, Russia four, England three, Austria two, and Belgium, Holland, Hungary, and Switzerland, each one. Many countries which do not provide for the continuous support of a seat are also represented by investigators at the Station, Japan being among the number.

An open letter giving much special and general information to students anticipating a session at Naples has been issued in French and German by the Director, who misses no opportunity of aiding those who wish to avail themselves of the advantages of the Station. The Institution has frequently been gratified on receipt of reports from its appointees by the warmly expressed appreciation, not only of the exceptional opportunities for research afforded at the Station, but also by mention of the obliging readiness of each member of the staff to further the advancement of investigators in every way possible.

It is a subject of congratulation among biologists generally that the Naples Station, after so many years spent in fostering an interest in research by its broad and successful administration, now finds it not only possible but necessary to add to its present buildings another already in process of construction at a cost of about $80,000. The ground floor of the new building is to contain zoölogical and botanical work-rooms, while the floors above will be devoted to experimental physiology and physiological chemistry, and the two galleries to occupy the space between the new building and the one on its right will be used for the rapidly growing library. In addition to the ample resources available for the use of students at Naples, the activity of the department for conserving and transmitting sea fauna to other countries for study purposes keeps pace with the constantly increasing demand, so that the station now provides university laboratories, museums, etc., in many parts of the world with materials for research.

In the interest of science and in order that the utmost possible benefit may be derived from the table supported by the Smithsonian Institution, it is desired that the aggregate time of appointments for each year shall equal the continuous occupancy of one student for the same period. With this object in view the conditions on which the seat is granted have been made such as can be reasonably complied with, so that while it is an advantage in the way of completing the permanent record of each occupant for an investigator to make as full a statement of his scientific history, publications, etc., as convenient, it is essential to submit with a request for a seat only such data as will show the capacity of the applicant for original work in embryological, histological, and other fields for which special facilities are offered at Naples.

Following is a list of the investigators who have been accredited to the Smithsonian seat, some of them for more than one session: F. W. Bancroft, C. H. Bardeen, H. C. Bumpus, R. Burton-Opitz, W. A. Cannon, C. M. Child, H. W. Conn, C. B. Davenport, B. M. Davis, B. M. Duggar, D. G. Fairchild, J. H. Gerould, C. W. Hargitt, V. G. Heiser, F. H. Herrick, H. S. Jennings, J. B. Johnston, F. M. MacFarland, B. M. Martin, S. E. Meek, P. C. Mensch, C. S. Minot, T. H. Morgan, D. M. Mottier, L. Murback, H. Osborn, C. W. Prentiss, F. L. Stevens, W. T. Swingle, W. G. Van Name, W. M. Wheeler, E. B. Wilson, H. V. Wilson.

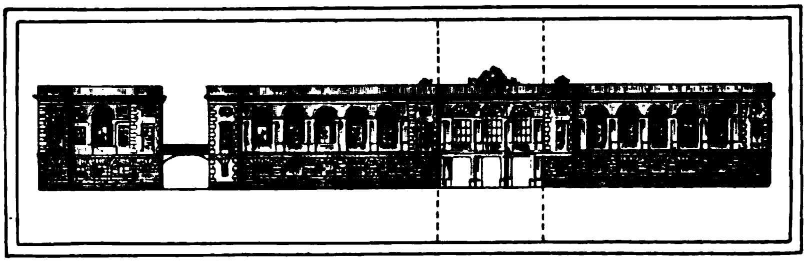


FIG. 17.—The Naples Zoölogical Station, showing addition to buildings.

NOTES

Dr. Carl Alfred Felix Flügel

In the death of Doctor Flügel, which occurred in Leipzig, February 6, 1904, the Smithsonian Institution lost a loyal assistant and an intelligent and capable representative. Doctor Flügel was appointed agent of the International Exchange Service of the Institution for Germany, Austria, and the adjacent countries in 1855, a position he filled for the remaining nearly fifty years of his life. He was the official successor of his father, Doctor Johann Gottfried Flügel, who was made agent of the Smithsonian Exchange Service, at the time of its organization in 1847, by Professor Joseph Henry, first Secretary of the Institution, he also having filled the position until his death in 1854. The son succeeded his father as United States vice-consul in Leipzig also, this position under the government proving likewise a life appointment in the case of both father and son.

Doctor Felix Flügel was scholarly in his tastes and occupations by both inheritance and training, the father having been the first lecturer in English in the University of Leipzig, where he received his doctor's degree in 1824, publishing in the same year a *Grammar of the English Language,* which remains a noteworthy record of the earlier period of English philology in Germany. Both father and son were persevering and laborious students in English, each publishing pamphlets and critical essays on the language, and each being the author of an English and German Dictionary, that of the son having become a standard work, which reached its fifteenth edition in 1891.

The long tenure of office of Doctor Felix Flügel gave him an exceptional opportunity to further the exchange work of the Smithsonian Institution throughout central Europe, and, believing that the system was an important medium of scientific intercourse between the United States and Europe, he labored untiringly for its development along practical lines, at the same time adding to exact business methods the charm of a personal courtesy and kindness which won many friends.

It would be difficult to overestimate the intelligent and faithful service rendered to the Institution for so many years by Doctor Flügel, and the appreciation of his character expressed by those officials whose fortune it was to come into personal relation with him is a sincere tribute to his capability and worth.

Notes on Some Malay Peoples

Dr. William L. Abbott, writing from Lower Siam, sends the following note to the Department of Anthropology of the United States National Museum:

"I have a good series of photographs of the Hastings Harbor Selungs. The men fish with spear, dive for shells, and make their own canoes. The women make baskets and mats and gather shell-fish. The Kopah Selungs are different both in race and language.

"The Selungs are a very mixed race, but I believe there is an original peculiar type amongst them, if it could be traced out. As for the Malay, there is no Malay type. I do not believe there is a native in the peninsula or in the archipelago west of New Guinea who is pure for fifty generations, except the Andamanese and Semangs and probably the Aetas. I, myself, cannot distinguish the various races among the Malays, leaving dress out of account. They are remarkably nomadic. Even the boundary line between the Siamese and Malays is very indefinite. This universal mixing up has been going on for ages, probably before the Mohammedan invasion; certainly more than ever it is going on now. The Menangkabo people of the Padang highlands are supposed to be the purest Malays; they have the purest language."

Professor Mason having written to Doctor Abbott inquiring why it was that all the collections that come from the southern Malay peninsula and northern Sumatra are dull-brown and somber in appearance, Doctor Abbott replies:

"About somberness of Malay coloring, I think it is rather dinginess. Mrs. Edmett, who was born in Selangor and was practically brought up with the children and grandchildren of the old sultan, says there are three bright colors very much used by the Malays on their festive occasions; a gathering of rajahs and chieftains on a gala day is a blaze of them. The sultan's color is a brilliant yellow; he wears a yellow handkerchief on his head and his umbrella is the same color. You will see a red umbrella close by and also a blue one. These three colors and also a bright magenta appear in most of their gorgeous sarongs, worn on state occasions, some of them a hundred years old, heavy with gold and silver thread and very precious. But the common, everyday things in use are undoubtedly dull or dingy. Everywhere the bazaars are full of cheap and gaudy sarongs, handkerchiefs, and jackets. The women are dingier than the men. The Malay, though clean in his person, is dirty in his everyday dress.

"Another thing about the Malay: Wallace said that he is quiet, stolid, and brooding. I do not know where Wallace kept his ears during his eight years in Malaya. They are polite and reserved before strangers and the older men are certainly quiet; but the younger men are as noisy as any people I have ever met, quite the equals of the Africans. The noise and pandemonium that arises from this small schooner of mine would awaken the dead. Some one or all of them are singing or shouting or talking at the top of their lungs from dawn to nine o'clock P.M., excepting during the heat of the day, when they all sleep.

"No children, neither Malay, Chinese, nor Kling, are noisy and disorderly like those of civilized races. It is really quite sickening to watch the boys coming out of the Raffles government school,—Chinese, half-caste, Malays, etc., all mixed up, walking out quietly and getting into rickshaws and garries and going along smug and clean. Nobody fighting, none of the scraps, couples in the gutter, tearing each other's clothes and hair—all of which gladden the bystander's eye as he watches the boys piling out of an English or American school, and which show the innate and pent-up energy of the race. But I think the depressing sameness and hotness of the climate has much to do with it; nobody has any energy to spare. The native of Hindustan seems gloomy by nature. The over-population of the country and periodical famines, etc., acting during many centuries, may be regarded as the cause of this. The Malay is not gloomy, but is rather a happy individual. Leaving out Java with its dense population, the Malay has the easiest and pleasantest life of any race. Hardly anywhere in his habitat is food scarce, and it is generally very easily obtained. I have not a very high opinion of the brain-power of the average Malay; but a Chinaman's brain is a sort of unawakened, or rather undeveloped, virgin soil of unimagined fertility. When China does awake, the world will be surprised; but I think the awakening will be by separate atoms, not as one mass, as was the case of Japan."

Materials Pertaining to Medicine

The Division of Medicine of the United States National Museum desires information and objects illustrative of the notions of the Filipinos, as well as of other Eastern peoples, concerning the origin and nature of disease and the methods of cure or prevention. The classification of remedies given below may be sufficiently suggestive of the kind of material wanted. Magic medicine will probably be found the most fruitful field to cultivate. Interesting specimens of native or old Spanish surgical instruments and appliances may also be discovered. Native drugs are always desired, if accompanied by facts concerning origin, methods of preparation, and uses. It should be remembered that the value of any museum specimen depends very largely on the amount of information that comes with it.

Classification for the Division of Medicine of the National Museum

A.—Magical Medicine: 1. Exorcism; 2. Invocation; 3. Incantation; 4. Amulets; 5. Talismans; 6. Fetiches ("Folk-medicine").

B.—Psychical Medicine: 1. "Laying on of hands," "Royal touch"; 2. Suggestion; 3. Hypnotism; 4. Faith-cure.

C.—External or Physical Medicine: 1. Baths, Massage, Exercise, Electricity; 2. Surgery, including Acupuncture, Cautery, Blood-letting, and Surgical Operations in general.

D.—Internal or Physiological Medicine: 1. Drugs, illustrated by: *a.* North American Indian medicine; *b.* Egyptian medicine; *c.* Greek medicine; *d.* Hindu medicine; *e.* Arabian medicine; *f.* Oriental medicine; *g.* Modern medicine.

E.—Preventive Medicine: 1. Water; 2. Air; 3. Food; 4. Beverages and Condiments; 5. Soils; 6. Habitations, Sewage; 7. Clothing; 8. Climate; 9. Disposal of the dead; 10. Disinfection.

Theories of Disease

(1) Disease a malevolent spirit, assuming material form either animate or inanimate, attacking the victim with or without provocation. Primitive.

(2) Disease a spirit, acting at the suggestion of a human enemy possessing supernatural powers (sorcery, witchcraft, conjury). Savage and half-civilized people.

(3) Disease caused by the angered spirits of the dead, either men or animals, or even plants. Savage and half-civilized people.

(4) Disease a punishment inflicted by an offended deity. Ancient; persistent.

(5) Disease due to the influence of the planets or other heavenly bodies (astrology). Arabians; persistent in Europe to the 17th century.

(6) Disease due to a variation in the relative activity of two controlling principles of life, viz.: heat and moisture, or "Yin and Yung," or the male and female principles. Persian, Chinese.

(7) Disease due to a disturbance in the relative proportions or

distribution of the fluids, or "humors," of the body, viz.: blood, phlegm, black bile, and yellow bile. Hippocrates, Galen ("Humoralists").

(8) Disease due to changes in the form, number, arrangement, or movement of the "atoms" of which the body is composed. Asclepias ("Solidists" or "Methodists").

(9) Disease due to the abnormal action of the dynamic or vital force ("Spirit," "pneuma," "Archæus"). Athenæus, Paracelsus, Hahnemann ("Vitalists").

(10) Disease considered only with respect to its manifestations or "symptoms," regardless of causes. Philenus, Sydenham, Hahnemann ("Empiricists").

(11) Disease due to various and complex modifications of normal structure and function, resulting from the conditions of environment or inherent tendencies. Modern scientific medicine.

Smithsonian Delegates

Doctor James B. Angell, President of the University of Michigan and Regent of the Smithsonian Institution, represented the Institution at the celebration of the fiftieth anniversary of the first commencement of the University of Wisconsin, held at Madison during the week beginning June 5, 1904.

Mr. William H. Holmes, Chief of the Bureau of American Ethnology has been appointed delegate of the Institution at the Fourteenth International Congress of Americanists to be held at Stuttgart, August 18–23, 1904.

Messrs. Leonhard Stejneger and Gerrit S. Miller, Jr., of the United States National Museum, will represent the Institution and the Museum at the Sixth International Congress on Zoölogy to be held at Berne, Switzerland, August 14–19.

Dr. Marcus W. Lyon, Jr., of the United States National Museum, was delegate from the Smithsonian Institution at the meeting of the International Congress on Education, held at St. Louis, June 28 to July 1.

Professor Paul Haupt, Honorary Curator of the Division of Historic Archeology, United States National Museum, has been appointed representative of the Smithsonian Institution and the National Museum at the Fourteenth International Congress of Orientalists to be held at Algiers in April, 1905.

Professor E. J. Marey

News has been received by cable of the death on May sixteenth of Professor E. J. Marey, member of the Institute of France and of other learned societies. Professor Marey, whose scientific activities have extended in many directions, is perhaps most popularly known through his researches in connection with the application of chronophotography to the investigation of the complicated acts of animal locomotion, which he carried successfully on to an analysis of the movements of organic life of which there is no conscious knowledge. In December, 1900, a grant was approved by the Smithsonian Institution in aid of the experiments of Doctor Marey on the analysis of air-currents by means of metro- and chrono-photography, a description of this successful and interesting research being published in the appendix to the report of the Secretary for 1901. Latterly, Doctor Marey was interested in the work of an international commission established for the control and unification of the methods of registration in biological experiments. A special commission was formed, of which Doctor Marey was made president, and steps were taken for the foundation in this connection of an institute bearing his name.

A Monument to Borghesi

The Smithsonian Institution has been informed that on September 3, 1903, a Committee of the *Patrizi* of San Marino was formed to promote a public subscription for the erection of a monument to Bartolemeo Borghesi in the city of San Marino, where the famous archeologist and epigraphist spent the greater part of his life and where he ended his days. On September 17 the Consiglio Principe of the republic issued a decree applauding the initiative thus taken and authorizing the regents to accept the invitation of the committee to become its honorary presidents. Following this auspicious beginning, the committee was still further favored with the gracious approval of H. M. the King of Italy and of the President of the French Republic. The committee now turns to the academies and scientific institutions of Europe, to all those who cultivate numismatics and archeology, to the Patricians of San Marino and to the consuls and friends of the republic, begging them by their contributions to aid in rendering due honor to their great fellow countryman.

The Lobatchefsky Prize

The Smithsonian Institution has been informed that at a formal meeting held in February, 1904, the Physico-Mathematical Society of Kazan, Russia, awarded the Lobatchefsky prize for 1903 to D. Hilbert, Professor of Mathematics in the University of Göttingen, for his treatise on the Fundamental Principles of Geometry, the work having been reviewed and reported on by Doctor Poincaré of the Institute of France. The works submitted by Messrs. Barbarin, Lemoine, Pieri, and Study were reviewed by Professors Mansion, C. A. Laisant, G. Peano, and D. Seiliger, and were distinguished by honorable mention. In recognition of the aid rendered in the examination of these works, the N. I. Lobatchefsky gold medal was awarded to Doctor Poincaré for his report on the treatise of Professor Hilbert, and Messrs. Mansion, Laisant, and Peano are to be made honorary members of the Society.

The Lobatchefsky prize of 500 roubles is bestowed triennially for works relating to geometry, preferably to geometry non-Euclidean, the Society being empowered to increase the value of the prize if the condition of the fund admits. Works printed in Russian, French, English, Italian, or Latin, and submitted during the six years preceding the date of an award, are eligible. The prize is not divided between competitors, but, in case of the reception of several works of equal value, it is awarded by lot. The fourth award will take place November 6, 1906. Competitive treatises will be received until November 4, 1905, and should be addressed to the Physico-Mathematical Society of Kazan, of which Doctor A. Vassilief is President.

RECENT PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

Continued from List of July, 1904, in Publication No. 1445

No.	*Title.*	*Series.*	*Price.*
1462	Powell, J. W. Twenty-first Report, Bureau of American Ethnology, 1899–1900 (*In press*).[1]		
1463	Powell, J. W. Twenty-second Report, Bureau of American Ethnology, 1900–01, Part I.[1]		
1464	Powell, J. W. Twenty-second Report, Bureau of American Ethnology, 1900–01, Part II (*In press*).[1]		
1465	Account of Smithsonian Institution, origin, history, objects, etc.		.10
1466	Langley, S. P. Exhibit of the Smithsonian Astrophysical Observatory at Louisiana Purchase Exposition		.10
1467	Smithsonian Miscellaneous Collections (*Quarterly Issue*) vol. XLVII, Part I (containing Nos. 1468–1476)	M.C. XLVII	1.00

[1] To be sold by the Superintendent of Documents, Government Printing Office, Washington, D. C.

THE SMITHSONIAN INSTITUTION

THE NATIONAL MUSEUM

BUREAU OF AMERICAN ETHNOLOGY

INTERNATIONAL EXCHANGES

NATIONAL ZOOLOGICAL PARK

ASTROPHYSICAL OBSERVATORY

Smithsonian

Miscellaneous Collections

QUARTERLY ISSUE

SMITHSONIAN MISCELLANEOUS COLLECTIONS

QUARTERLY ISSUE

The Quarterly Issue of the Smithsonian Miscellaneous Collections is designed chiefly to afford a medium for the early publication of the results of researches conducted by the Smithsonian Institution and its bureaus, and especially for the publication of reports of a preliminary nature. It is not intended that the Quarterly Issue shall supersede the regular series of the Smithsonian Miscellaneous Collections, but, as its name implies, shall form a part thereof.

Following the long established custom of the Institution, all contributions submitted for publication in the Quarterly Issue will be referred to a committee, on whose judgment of the value and suitability of such contributions the Institution will be guided.

The Quarterly Issue will be published about the first of January, April, July, and October. Each number will consist of about 144 pages and will be suitably illustrated.

CONTENTS

LENOPHYLLUM GUTTATUM ROSE

VOL. 47 1904

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 2 QUARTERLY ISSUE PART 2

LENOPHYLLUM, A NEW GENUS OF CRASSULACEÆ

BY N. L. BRITTON AND J. N. ROSE

LENOPHYLLUM Rose, gen. nov.

Perennials, branching at base. Leaves a few opposite pairs, clustered near the base, very thick, somewhat flattened, more or less deeply concave on the upper surface. Inflorescence erect, of a few equilateral racemes or interrupted spikes; flowers sessile or nearly so. Calyx of 5 erect equal nearly distinct sepals. Corolla yellow or drying reddish; lobes erect, only the upper portion spreading or recurved, narrowed at base and therefore not touching each other. Stamens 10, the five opposite the sepals distinct, the other five borne on the petals; carpels narrow, erect; styles slender, at first erect, only a little spreading in age.

Four species, all of northeastern Mexico and southern Texas.

Type species, *Sedum guttatum* Rose.

The type of this genus was first described by Mr. Rose as a doubtful Sedum, its distinct petals excluding it from all the other related genera. Living specimens show little connection with Sedum, but in foliage and habit more resemble Echeveria, from which, however, they are clearly distinct.

The discovery in 1903 of two additional species of similar habit, foliage, inflorescence, petals and carpels, together with the recognition of a fourth in the hitherto doubtful *Villadia texana,* justifies the segregation of the genus from Sedum.

While this paper is going through the press a fifth species has been received. Flowering material has not yet been obtained and we have thought best not to publish the species at this time. We have living material from which a full description may be drawn and published later.

Key to Species of Lenophyllum

Leaves obtuse or rounded at apex.	
Leaves broad at base.	1. *L. guttatum.*
Leaves narrow at base.	2. *L. weinbergii.*
Leaves acute.	
Pairs of leaves distant; corolla greenish-yellow.	3. *L. acutifolium.*
Pairs of leaves not distant; corolla "rosy yellow."	4. *L. texanum.*

1. LENOPHYLLUM GUTTATUM Rose

(PLATE XX)

Sedum guttatum ROSE, Bull. N. Y. Bot. Garden 3: 42. 1903.

Much branched at base; shortly caulescent; leaves glabrous, opposite, of 2 to 4 pairs, 2 to 3 cm. long, thickish, rounded on the back, broadly channeled on the face, of a sage-gray color blotched with purple-black, obtuse; inflorescence 3- or 4-branched; pedicels very short or wanting; sepals free nearly to the base, oblong, 3 to 4 mm. long, equal, green, obtuse; petals narrowly oblong, 5 mm. long, obtuse, yellow but in old flowers drying reddish, free to the base; stamens 10, shorter than the petals; the 5 opposite the sepals free to the base, the other 5 borne on the petals, attached about one-third the way up from the base; scales small, obtuse; carpels 5, distinct to the base, erect; styles about as long as the carpels, slightly spreading in age.

Common in the crevices of the most exposed rocks on summit of hill at Saltillo, Mexico.

Collected by Dr. E. Palmer, in 1902 (no. 309), and now in cultivation in Washington and at the New York Botanical Garden. It has repeatedly flowered at both places.

The original description of the species was drawn from vegetating plants and poorly preserved flowering specimens, and this has necessitated some slight changes in the description, especially with respect to the inflorescence and color of the flowers.

Explanation of Plate XX.—Fig. *a*, plant with well-developed inflorescence; *b*, another plant with inflorescence not developed; *c*, flower; *d*, petals and stamens; *e*, carpels; *f*, cross-section of leaf. Fig. *a*, *b*, *f*, natural size; *c*, 2½ times natural size; *d*, *e*, 3 times natural size. (All the illustrations in this paper are from drawings by the late F. A. Walpole.)

2. LENOPHYLLUM WEINBERGII Britton, sp. nov.

(FIGURE 18)

Glabrous, pale green; plants flowering from cuttings at the height of 5 cm., and in that stage unbranched; lower leaves rhombic-obovate, very fleshy, trough-shaped, about 1.5 cm. long and 1 to 1.5 cm. wide, narrowed but blunt at the apex, cuneate-narrowed at the base, opposite, ascending, the upper pair much smaller; bracts 3 mm. long or less; sepals distinct, spatulate-oblanceolate, obtuse, narrowed below, 3 to 4 mm. long, obtuse; petals oblanceolate, obtusish, yellow, a little

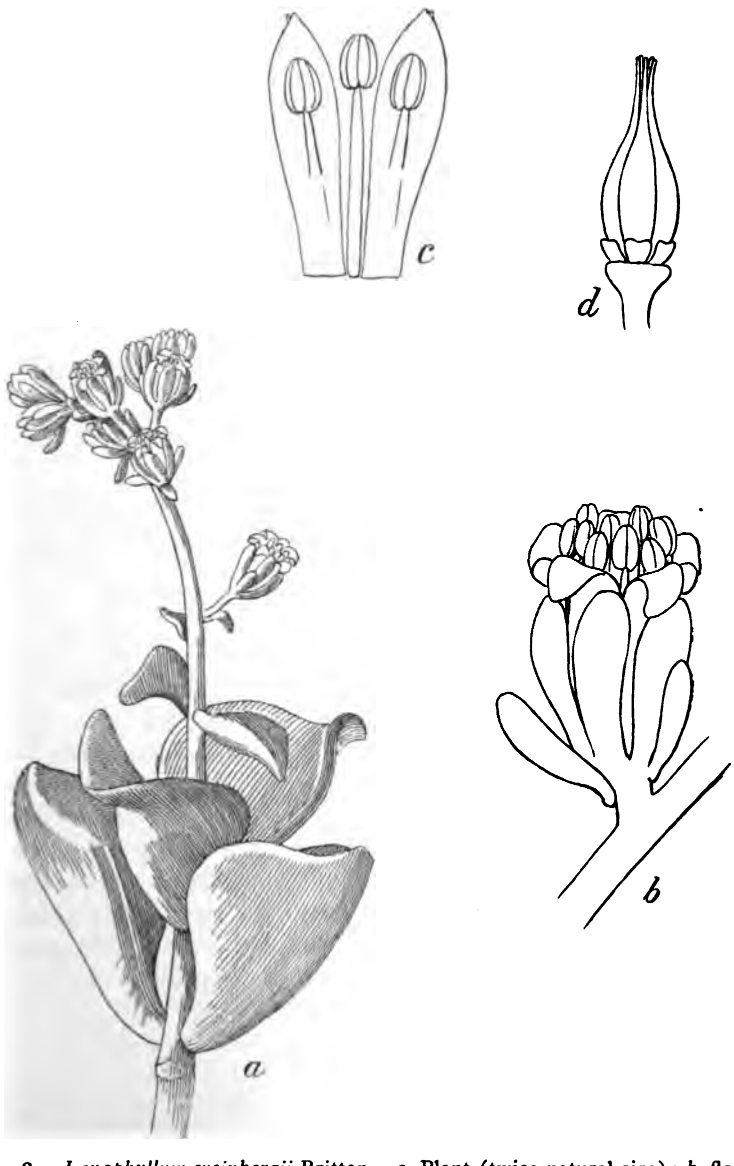


FIG. 18.—*Lenophyllum weinbergii* Britton. *a*, Plant (twice natural size); *b*, flower (five times natural size); *c*, petals and stamens (six times natural size); *d*, carpels and scales (six times natural size).

longer than the sepals, erect with reflexed tips; stamens a little shorter than the petals; young carpels erect, the styles subulate.

In cracks of rocks on high mountains in the northeastern part of Mexico, State of Coahuila, from the collections of Mr. McDowell in the City of Mexico, transmitted to the New York Botanical Garden, December, 1903, by Mr. Frank Weinberg.

3. LENOPHYLLUM ACUTIFOLIUM Rose, sp. nov.

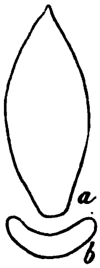


FIG. 19.—*Lenophyllum acutifolium* Rose.

Perennial, much branched at base; leaves opposite, 6 or 8 pairs, thickish, deeply channeled above, acute; flowers scattered in an interrupted spike or equilateral raceme, sessile or subsessile, borne in the axils of small bracts; sepals subequal, thickish, acute; petals greenish-yellow, distinct, erect below, the upper spreading or reflexed, acute; the 5 stamens opposite the sepals distinct, the other five borne on the petals; scales broad, truncate at apex; carpels erect; styles slender.

Collected by C. G. Pringle near Monterey, Mexico, in 1903.

Type in U. S. National Herbarium (no. 396,786) and living plants in succulent house, Department of Agriculture.

4. LENOPHYLLUM TEXANUM (J. G. Smith) Rose

Sedum texanum J. G. SMITH, Rep. Mo. Bot. Gard. 6: 114. *pl.* 50. 1895.
Villadia texana ROSE, Bull. N. Y. Bot. Gard. 3: 3. 1903.

Sedum texanum was very reluctantly referred by Mr. Rose to his new genus Villadia, but as it possessed a slender spike-like inflorescence, small flowers, erect carpels, etc., there seemed to be no other place for it. A reëxamination, though of rather poor material, shows that Mr. Smith's illustration and description are somewhat faulty, for the scars on the stems indicate opposite leaves, which are thick and fleshy like those of *Lenophyllum acutifolium,* while the inflorescence is not secund but equilateral. It differs from Villadia in having distinct petals, opposite, broad, trough-shaped leaves, etc.

Type in Herb. Mo. Bot. Gard.; duplicate type in U. S. National Herbarium.

PORTO RICAN STONE COLLARS AND TRIPOINTED IDOLS

By J. WALTER FEWKES

INTRODUCTION

Before their discovery the aboriginal inhabitants of the West Indies had developed a culture which was peculiar, and only distantly related to that of the mainland of America. The peculiarities of this culture are indicated by characteristic stone objects, the geographical distribution of which determines its boundaries. The centers of this peculiar Antillean culture were Porto Rico and Santo Domingo, but its influence was felt more or less strongly throughout all the West Indian islands.

Porto Rico has furnished the student of prehistoric life two distinctive types of polished stone objects, one of which is commonly called the stone collar, the other the tripointed idol. We occasionally find representatives of these types on the neighboring islands, but as they never occur in such abundance nor so elaborately made as those of Porto Rico, we are justified in regarding them as having originated on the latter island.

While it is difficult to enumerate the stone collars of Porto Rico, there is no doubt that the number collected on that island exceeds that of all the other Antilles. The Latimer collection in the National Museum at Washington had originally thirty-five specimens. A few have been taken from this collection, but fourteen have been added to it by my expeditions of 1902–1903. The American Museum of Natural History in New York also has many stone collars, including six complete specimens and several fragments, mentioned in the catalogue of his collection by Dr. Stahl.[1] Many of the European museums, as those in Copenhagen, Berlin, Paris, London, and Salisbury,[2] also have specimens of Porto Rican stone collars. In the Madrid Museum there were three, which, according to Navarette, were presented by Don Cecilio de Lara y Castro of Badajoz, and there are several in private hands in Porto Rico and in Europe.

[1] *Los Indios Borinqueños, Estudios Etnográficos;* Puerto Rico, 1889.

[2] See Stevens, *Flint Chips, A Guide to Prehistoric Archæology as Illustrated by the Collection in the Blackmore Museum, Salisbury;* London, 1870.

Possibly there are altogether a hundred specimens the ownership of which is known.

Few of these objects have been found in the other West Indian islands; none has been reported from Cuba and Jamaica, the Bahamas have not yet yielded a single specimen, and they are likewise unknown from the coast of North or South America. I have seen stone collars said to have been found in Santo Domingo, and other authors mention their occurrence on that island. In his account of the Guesde collection, Professor Mason[1] figures a collar "from Santo Domingo probably obtained in Porto Rico," and one or two stone collars are reported from this island by others. It is instructive to note, in view of their geographical distribution, that the recorded localities of known Dominican specimens are from the eastern or Porto Rican end of the island.

A few of these objects have been recorded as from the Lesser Antilles, but I have seen none in local collections on St. Kitts, Barbados, Dominica, Grenada, or Trinidad. Pinart,[2] after mentioning several specimens from Porto Rico and Santo Domingo, reports one each from St. Lucia and Dominica. No reference to stone collars from the Lesser Antilles occurs in Mason's catalogue of the Guesde collection.

Stone collars are found in Mexico and Central America, but I find no authority for the statement that those of the Porto Rican type occur on the mainland. In his comments on Dr. Stahl's statement[3] that these collars have been found in Mexico, Sr. A. Navarette[4] writes that none of them is in the National Museum at the City of Mexico, and that they are not mentioned by Chavero, who has described at length the stone objects of that republic.[5] As Dr. Stahl suggests, the stone collars in the Lesser Antilles were probably carried there from Porto Rico by the Caribs, and were not made by the inhabitants of those islands. Navarette thinks that the same people may also have carried these objects to Mexico, if we accept the statements that they occur in that country.

---

[1] *The Guesde Collection of Antiquities in Pointe-à-Pître, Guadeloupe, West Indies;* Smithsonian Report, 1884; reprint, 1899, fig. 199, p. 827.

[2] *Note sur les Petroglyphes et Antiquites des Grandes et Petites Antilles;* Paris, 1890, p. 12.

[3] *Los Indios Borinqueños,* p. 45.

[4] *Estudios de Arqueologia de Puerto Rico. Resultados de una excursión cientifica,* VI. The newspaper *Aguila,* Ponce, 1904.

[5] Many Mexicanists have described stone yokes and stone collars which differ in details from those of Porto Rico. Whether or not there is any relation between the two is yet to be investigated, but the resemblance in general form indicates some connection.

Collars are said to have been found in caves, but thus far we have no reliable information on this point, and no one has yet recorded an account of their association with other aboriginal objects in such places. I have fully investigated many of the stories regarding the cave origin of these collars, but have found them always to be based on hearsay. A reliable man at Ponce informed me that he had seen two of these collars in a cave and that they were lying side by side and luted to the floor. Between them, according to his account, there was a tripointed stone, and back of them was a low, artificial banquette. I have not myself found collars in caves, but the persistency of testimony that they occur in such places, as well as the fact that caverns were formerly places of worship, is evidence that these objects sometimes occur therein. Porto Rican shell-heaps, of which several have been explored, have thus far failed to yield a specimen of stone collar. These objects are generally plowed up in the fields or are brought to light by chance excavation in unexpected places.[1]

The technique of both the collars and the tripointed stones is among the best known to the student of aboriginal American stone art, and it is remarkable that man was able to cut and polish hard stone so skilfully without the aid of iron implements. In both types there are some specimens the surfaces of which are almost as smooth as glass; while on the other hand many are roughly made, showing signs of the instrument used in pecking. Evidences of erosion are found on the surfaces of several, some of the most common of which are made of a kind of breccia in which the harder, angular, enclosed fragments stand out in relief from the eroded softer matrix. The surface in several specimens is decorated with incised geometrical figures.

There are indications that the tripointed stones were sometimes varnished or covered with a gum or resin similar to that found on wooden idols, while the surfaces of others, as that of a bird-shaped, tripointed stone in the Museo Arqueologico in Madrid, retains traces of pigment. Although as a rule the surfaces of the tripointed stones are plane, one or two of them bear small, superficial, wart-shaped prominences, evidently intentionally made, and with considerable skill. Several specimens have surface pits or shallow depressions the significance of which is not apparent. These are generally two in number, one on each side, and in a few cases two on each side; others have four such depressions, two on the sides and two on the anterior and pos-

[1] While I was in Ponce, Porto Rico, in April, 1904, a plowman turned up one of these objects in a cane-field on the outskirts of the city.

terior of the cone. In one specimen with two such pits each is surrounded by or enclosed within a raised rim; in others a limb is carved in relief extending forward from this rim. In one or two examples, which have a fillet cut in relief on the forehead, there is a median pit in this band as in some stone masks. In the majority of specimens the depressions evidently once served as places for the attachment of shell or gold ornaments.

The use and meaning of the tripointed stones and collars are enigmatical. No reference is made to them by writers of the sixteenth, seventeenth, and eighteenth centuries, although they often describe the customs of the Indians in considerable detail. The absence of references to these remarkable objects by those contemporary with the natives has led some later authors to regard them as prehistoric, and as having passed out of use before the advent of the Spaniards. The first reference to stone collars and tripointed stones dates back to the middle of the nineteenth century, long after the culture to which they owe their origin had disappeared.

CLASSIFICATION OF STONE COLLARS

Professor Mason distinguishes two classes of stone collars, which he calls "the massive oval, and the slender oblique ovate, or pear shaped." "The latter," he says,[1] "are far more highly polished and ornamented than the former, and some of the ornamental patterns on the massive forms are reproduced but more elaborated on the slender variety, notably the gourd-shaped ridge surrounding the panels."

Collars of both the above classes are subdivided by the same author into two groups—(*a*) the right-shouldered, and (*b*) the left-shouldered collars, which may be distinguished as follows: If we imagine the collar placed over the neck, with its smooth edge resting on the chest and the pointed pole hanging downward, the collar may be called left-shouldered when the projection "faintly resembling a lashing of the two ends of a hoop" is on the wearer's left side and the decorated panel on the right. When, however, these portions have reversed positions, the collar is called right-shouldered. Certain of the massive collars have no superficial decoration, but are simply perforated stones, possibly unfinished specimens.

The general characters of the two groups of stone collars, massive

[1] *The Latimer Collection of Antiquities from Porto Rico in the National Museum*, and *The Guesde Collection of Antiquities in Pointe-à-Pître, Guadeloupe, West Indies;* reprint, 1899, p. 385. These articles originally appeared in the Smithsonian Reports for 1876 and 1884 respectively.

(plate XXI) and slender oblique ovate (plate XXII), differ to such an extent that it would seem as if their uses were not the same, and the differences in the symbolic markings on their surfaces would imply a different interpretation of their meaning. For instance, while the theory that these collars were worn over the neck applies fairly well to the slender ovate variety, it fails to apply to some of the massive forms. Although the latter might be regarded as objects of torture or symbols of servitude, this interpretation would hardly hold for the slender examples. On the other hand, it cannot be reasonably claimed that the use and meaning of the two groups

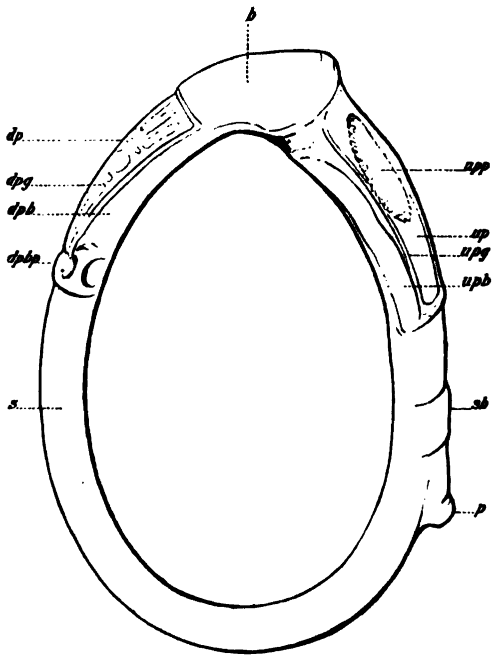


FIG. 20.—Schematic drawing of a slender, oblique stone collar.

were different, considering the similarity in their general forms; nor is it probable that the massive forms are unfinished specimens of the slender ones, inasmuch as the special superficial symbolic characters of each group are too well defined to suppose that one could be made out of the other.

There are certain regions of both the massive and the slender collars which can readily be identified and which for convenience have been designated by the following names: *b*, boss; *p*, projection; *s*, shoulder; *sb*, shoulder ridge; *dp*, decorated panel; *dpb*, decorated panel border; *dpg,* decorated panel ridge; *dpbp,* decorated panel border perforation; *up,* undecorated panel; *upg,* undecorated panel pit; *upb,* undecorated panel border; *upr,* undecorated panel ridge. These regions occur in reversed positions in right- and left-handed collars, and vary in form according to the simple or elaborate character of the ornamentation.

b. Boss.—The so-called boss is a rounded, generally unpolished, prominence or swelling, well marked in slender but absent in massive collars, being generally undecorated, and so situated that it separates the two panels. In massive forms the boss is confluent with the undecorated panel, but in the slender it is evidently a continuation of the decorated panel.

p. PROJECTION.—The projection, which is a significant feature of the collar, has the form of a slight swelling or a rounded elevation, closely appressed to the body of the collar, to which it appears to be bound by an encircling shoulder ridge or fillet. In massive collars there are generally two protuberances, which may be called projections, one on each side of the ridge; but in slender collars there is only one, which emerges from under the shoulder fillet on the side opposite the boss. Sometimes the projection is ferruled, often with pits like eyes, and in one collar the prominence is said to have the form of a snake's head.[1]

sb. SHOULDER RIDGE.—The shoulder ridge is a raised band, cut in low relief, partly encircling the collar near the base of the projection, which it appears to bind to the body of the collar. It is sometimes broad and flat, but more commonly is a narrow bead, and in massive forms where there are two projections it fills the interval between them. Rarely absent, it is seldom in very high relief.

dp. DECORATED PANEL.—This term is applied to that region of the collar which lies adjacent to the boss, and on the side opposite the projection. Although the name is a useful one for distinguishing this part in many specimens, this panel, although generally smooth, is not ornamented. The general outline of the decorated panel of oblique ovate collars is quadrate or trapezoidal, with or without a marginal panel ridge formed by a shallow groove. In the massive forms the outline of this panel is often triangular. The superficial decoration of the panels of massive collars, when present, is less elaborate than that of the slender ones, and consists mainly of pits, incised circles, triangles, or parallel lines. Figures of faces

[1] This specimen is owned by Mr. Leopold B. Strube, of Arecibo, who has sent to me a drawing which shows the knob in the form of a snake's head.

with eyes and mouth are sometimes cut on this panel, which is ordinarily smooth, its surface slightly convex, and often highly polished.

dpb. DECORATED PANEL BORDER.—The margin of the decorated panel is called the panel border. In oblique ovate collars this border is cut in the form of a ridge looped into scrolls, often with pits resembling eyes. In massive collars this border is sometimes pinched up into three triangles. An examination of the decorated panel border in several specimens of slender collars reveals a conventional face with representations of ear pendants on each side. In others the face and ears appear on the panel border, but are more conventionalized. The best specimens of panel border decorations are scroll figures.

dpg. DECORATED PANEL RIDGE.—A groove bounding the decorated panel and separating it from the panel ridge often marks the limit of the panel. In oblique ovate collars this ridge is generally pinched up into an elevation at one angle of the panel, which is perforated, thus forming the decorated panel border perforation. The object of this perforation (*dpbp*) is unknown, but the care with which the ridge is modified at this point indicates that it must have been an important one. Massive ovate collars have no perforated angle of the panel.

up. UNDECORATED PANEL.—The undecorated panel lies between the shoulder ridge and the boss; it has a panel ridge but no decorated panel border. In massive oval collars the undecorated panel is simply a rough, slightly convex plane extending from one of the projections to the pole of the collar, the boss in this variety being absent. In many of the oblique ovate collars there is a pit (*upp*) or elongated shallow depression in the middle of this panel, but this is absent in the massive type. The meaning of this pit is unknown, but its rough surface suggests that it may have been the place of attachment of an ornament like a nugget of gold or a fragment of shell. On the Acosta theory that a head was formerly attached to the collar, the rough surface of this panel may have been the place of union, in which case the pit in the middle of the panel would serve to strengthen the attachment. The undecorated panel often has a panel groove (*upg*) and border (*upb*), but neither of these is so elaborately decorated as the corresponding region of the decorated panel. The rough surface of the undecorated panel is constant in all collars, indicating that it was hidden or covered in some way.

TRIPOINTED STONES

Not less enigmatical than the collars are the characteristic tripointed stones, which, like the collars, reach their highest development, both artificially and numerically, in Porto Rico. While these objects were common on that island, they have not been found in Jamaica, the Bahamas, Cuba, or the Lesser Antilles. I have seen one or two from Santo Domingo, but their geographical distribution is practically the same as that of the stone collars.[1] As their name indicates, the tripointed stones are characterized by their trifid form, sometimes more or less obscure. Mason designates this group of stone objects as "mammiform," a term specially applicable to many specimens, whereas all show the trifid form which has suggested the designation *tripointed.*

The three projections which characterize this form may be designated as follows: Supposing the object placed so as to rest on the flat, slightly concave side, the vertical projection opposite this base may be called the conoid projection, and the other two points, or those at each end of the base, the anterior and posterior projections. In a comparative examination of tripointed stones it is convenient to place the specimen so that the anterior projection points to the observer's left hand.[2] That surface which is turned to the observer may then be called the proximal, and the opposite the distal surface. The flat, slightly concave side between the anterior and the posterior projections upon which the object rests may be known as the base.

In general appearance, as pointed out by Professor Mason,[3] these "objects present in more than one-half of the specimens, the image of a human figure lying on the stomach, with the face more or less upturned, the mouth open, and the countenance wearing a tortured look. The other end of the stone represents the lower extremities of the body, so doubled up as to expose the soles of the feet against the rump. On the back of the prostrate form is a conoid prominence, beautifully rounded up, straight or slightly concave in outline in front, a little convex in the rear, swelling out on one side slightly more than on the other, and descending more or less lower than the top of the head and of the rump so as to form anterior and posterior furrows. The whole appearance cannot fail to remind the student of the legend of Typhœus killed by Jupiter with a flash of lightning and buried beneath Mount Ætna."

[1] Pinart (op. cit.) gives their distribution as Porto Rico, Santo Domingo, St. Thomas, and Vieques islands.

[2] In specimens of the fourth type, where no head is cut on the stone, the same relative orientation may be obtained by placing the specimen so that the apex of the conoid projection turns slightly to the left.

[3] Op. cit., pp. 379–380.

Classification of Tripointed Stones

The tripointed stones may be classified as follows: 1, Tripointed stones with head on the anterior, legs on the posterior point. 2, Tripointed stones with face on one side of the conoid projection. 3, Tripointed stones with the conoid projection modified into a face. 4, Smooth tripointed stones without head, face, legs, or incised ornamentation.

The majority of these stones belong to the first group or type, in which the head and legs are always represented, although often obscurely, one on each of the basal projections. There are intermediate forms which connect these types with trilobed stones and aberrant forms which resemble them, the true identification of which is doubtful.

1. *Tripointed Stones with Head on the Anterior and Legs on the Posterior Projection.*—This type (plates XXIII, XXIII*a*), which is fairly well represented in all collections from Porto Rico, is well defined and easy to recognize. As a rule the distance between the anterior and posterior points (head and legs) is somewhat greater than the apex of the cone or height when resting on the base, and the conoid projection tips a little forward. The axis from head to legs is generally straight, but sometimes it is slightly warped. The surface is often decorated with incised geometrical lines, pits, and excrescences like warts. The main differences in this type are found in the forms of the heads and legs, which may resemble those of birds, lizards, mammals, or human beings. In rare instances both interior and posterior limbs are cut on stones of this type—the former at the base of the conoid projection, the latter on the posterior point.

Mason figures, from the Latimer collection, three specimens of this type with birds' heads.[1] One of these, according to this author, has the head of a "sea bird," another that of a "parrot," and the third is "parrot or owl-shaped." In the Neumann collection, purchased by me in 1904 for the National Museum, there is an instructive specimen of bird-headed tripointed stone of the first type, which differs somewhat from those in the Latimer collection. It has a long, curved beak, but no representation of wings and no well-defined legs.

One of the most interesting of the tripointed stones, representing a bird, is in the Archeological Museum of Madrid, Spain. A glance at this object shows, cut on the anterior point, a bird's head with the bill turned backward between the eyes toward the conoid process. Extending from the head posteriorly on each side there is a raised oval area carved in low relief with geometrical figures, as circles, dots,

[1] Op. cit., figs. 36, 39, and 41.

and lines. These areas apparently represent wings, being decorated with the same designs as the wings of an undoubted image of a bird in the Smithsonian collection.

It will be noted that by this identification the relative position of the conoid projection to the body differs from that of this part in other tripointed idols. It rises from the ventral, not the dorsal, region of the animal represented. The base of the idol is the back of the bird. Posterior appendages fail, as is commonly the case in most of the tripointed stones with bird's heads.

Some of the specimens[1] of the first type have heads with protuberant snouts like those of frogs and reptiles. Mason has suggested that one of these may represent the head of an alligator,[2] but it seems to me more likely that this particular idol was intended to indicate an iguana. The suggestion of the same author that the aborigines represented the head of a hog or peccary in another of these stones (fig. 40) loses force when we recall the fact that neither the hog nor the peccary belonged to the precolumbian fauna of Haiti or Porto Rico.

The number of tripointed stones with human faces exceeds those with bird or other animal heads, a fact which tells in support of the anthropomorphous character of the majority of these idols. Like those with animal heads, these human forms have two legs cut on the posterior point, but none appears to have representations of anterior appendages.

Several specimens of the first type, with lizard heads, have anterior legs cut on the sides of the conoid projection as well as the hind legs on the posterior point. One of the best of these (plates XXIII, XXIII*a*), apparently representing a reptile, was found with two others by Mr. Zoller in a cane-field at El Carmen farm, near Salinas, Porto Rico. The anterior legs are incised on the surface of the body, but the posterior legs are cut in high relief and appear to be drawn to the rump. Both pairs of appendages have pits on the first joint, giving to the posterior point the appearance of the eyes of a carved head. A superficial view of this idol might lead one to suppose that it was bicephalic, or that a head was carved on the posterior as well as on the anterior point. A closer study of the specimen and a comparison with others, however, show that the intention was to represent legs, not a head, on the posterior projection; what might be called eyes are pits in the thighs for ornaments, the fancied nose is a short, stumpy tail, and the mouth is simply a space between the toes.

[1] Mason, op. cit., fig. 40; also No. 17007, p. 383.

[2] Ibid., fig. 44.

2. *Tripointed Stones with Face on one Side of the Conoid Projection.*—In this type (plate XXIV) a face is cut in the interval between the apex of the conoid projection and the anterior point. Posterior limbs are generally absent, but anterior limbs may be represented, and in one specimen both are found.

Comparatively speaking, this is a rare type, only two specimens having been figured by Mason[1] from Porto Rico and one by the present writer from Santo Domingo.[2] In 1903 I was fortunately able to add two more specimens of this type to our collections; one of these was purchased from Señor Angelis of Cataño, the other from Señor Hernandez of Loquillo. The latter is figured in my Preliminary Report[3] of the expedition of 1903, the former in an accompanying illustration (plate XXIV).

Mason[4] gives the following description of one of the representatives of this type in the Latimer collection: "A curious specimen, made of mottled, flinty limestone. The projecting ends are entirely wanting. The front of the mamma or cone exhibits a grotesque human face. The rear is carved to represent a frog, whose nose forms the apex of the stone, and whose back and hind legs, drawn up, fill the remaining surface. The fore-legs pass down the sides of the cheeks and under the lower jaw of the human face in front. This is truly a marvel of aboriginal art, and may be set down as the best specimen of this class in the collection."[5]

The Cataño specimen (plate XXIV) is destitute of representation of posterior appendages or anterior legs on the sides of the conoid protuberance. The ears have the form of a figure 6, with shallow pits as if for the insertion of metal ornaments. The surface (plate XXIV, *c*) of this specimen is decorated with incised geometrical figures, as circles and triangles, resembling those on other Antillean objects.

Another tripointed stone of the same type was purchased by me in 1903 at Loquillo, near the eastern end of Porto Rico. This object has a comparatively rough surface, with anterior extremities, flexed

[1] Op. cit., figs. 42, 43.

[2] *On Zemes from Santo Domingo*, American Anthropologist, orig. ser., vol. III, 1891.

[3] *Preliminary Report on an Archeological Trip to the West Indies*, Smithsonian Miscellaneous Collections, vol. 45, Quarterly Issue, vol. I, 1903, pl. XLIII, 6.

[4] Op. cit., p. 383.

[5] Although the position of the hind legs resembles that of a frog's legs, it is practically the same as in tripointed stones with human and lizard heads. We might equally well say that many of the tripointed stones of the first type represent frogs.

forward, cut on the side of the conoid projection. No posterior limbs are represented. On the chin there are incised parallel lines which may represent fingers, but which also remind one of the so-called beard in some of the Porto Rican pictographs.[1]

3. *Tripointed Stones with the Conoid Projection Modified into a Face.*—This almost unique type is represented by two specimens from Santo Domingo, figured in my Preliminary Report for 1902–03,[2] and a third an illustration of which accompanies this article (plate XXV). In addition to the head, the first has rude representations of legs carved on its sides. In the second specimen, which is without legs, the snout is much elongated and the regions corresponding to the anterior and posterior projections of the first and second types are pointed. In the two described specimens of this type the base, like that of other tripointed stones, is slightly concave.

In the winter of 1903–04, I purchased, in the Neumann collection, another, the third known specimen, of this rare type of tripointed idols. While this object (plate XXV) resembles somewhat the two already mentioned, it is smaller, better carved, and more elaborately decorated. The material of which it is made is white marble, somewhat weather-worn, but not enough to destroy a fine network of incised decoration, which may be especially seen on the fillet over the eyes. Legs are represented as on the other specimens of this type, and the eyes and nostrils are also evident. It is possible that this idol represents a lizard (perhaps an iguana), or some similar animal.

Tripointed stones of the third type bear a remote likeness to the Porto Rican stone masks in which the conoid projection has been completely replaced by a nose, the anterior and posterior points having been reduced to chin and forehead. From such masks the transition is easy to oval stone disks with faces cut either in relief or in intaglio, but here all resemblance to the tripointed stones becomes lost.

4. *Smooth Tripointed Stones.*—This group (plate XXVI, 1, 2) includes those stones of tripointed form which are devoid of face or legs and all superficial decoration. Although this type has the same general form as the others, the specimens belonging to it, as a rule, are much smaller, one of them being only an inch in length. Some of the aberrant members (plate XXVI, 3) of the type have en-

---

[1] *Prehistoric Porto Rican Pictographs,* American Anthropologist (N. S.), vol. 5, No. 3, 1903.

[2] *Smithsonian Miscellaneous Collections,* 1903, vol. 45, Quarterly Issue, vol. 1, pl. XLIV, 3, 4.

largements on the posterior and anterior points, obscurely representing heads and feet. These may be regarded as connecting links between this and the first type.

THEORIES OF THE USE OF STONE COLLARS

The theories[1] that have been advanced in explanation of the use of the Porto Rican ring-stones are almost as numerous as the writers on the subject; but unfortunately not one of the theorists has carried his hypothesis far beyond a simple suggestion. It may be interesting to mention a few of these theories, limiting the references to stone collars found in the Antilles, and waiving for the present a discussion of their relationship to the stone yokes and collars of Mexico and Central America, concerning which there is considerable literature.

Mr. Josiah Cato[2] writes thus of one of these collars brought from Porto Rico by Mr. E. B. Webb:

"With regard to the probable use or purpose of these rings, I can give no information, but shall be very much obliged for any suggestion or for hints as to any works likely to contain such an account of the customs of the nations at the time of the Spanish invasion, as may afford a clue to the mystery. Such elaborate pieces of work in hard stone could not have been intended to serve either a temporary or trifling purpose. They are all far too heavy for ordinary use, but yet not heavy enough to kill or even to greatly torture the wearer, if we regard them as collars of punishment."

One of the early references to these collars occurs in Dr. Daniel Wilson's work on *The Archæology and Prehistoric Annals of Scotland* (pp. 156–157):

"But perhaps the most singular relics of the Stone Period ever discovered in Scotland are two stone collars, found near the celebrated Parallel Roads of Glenroy, and now preserved at the mansion of Tonley, Aberdeenshire. They are each of the full size of a collar adapted to a small Highland horse; the one formed of trap or whinstone, and the other of a fine-grained red granite. They are not, however, to be regarded as the primitive substitutes for the more convenient materials of later introduction. On the contrary, a close imitation of the details of a horse collar of common materials is attempted, including the folds of the leather, nails, buckles, and holes for tying particular parts together. They are finished with much care and a high degree of polish, and are described as obviously the workmanship of a skilful artist. Mr. Skene, who first drew attention to these remarkable relics, suggests the probability of the peculiar natural features of Glenroy having led to the selection of this amphi-

[1] Acosta's theory that the tripointed stone was united to the stone collar, forming a serpent idol, is considered at the close of this article.

[2] *Proc. Society of Antiquaries*, 2d ser., vol. IV, no. 5, pp. 215–216.

theater for the scene of ancient public games; and that these stone collars might commemorate the victor in the chariot race, as the tripods still existing record the victor in the Choragic games of Athens. But no circumstances attending their discovery are known which could aid conjecture either as to the period or purpose of their construction."

Although these collars may have been found at Glenroy and have been ascribed by Dr. Wilson to the stone age of Scotland, they are evidently Porto Rican in origin, having been carried to Scotland from over the seas. Stephens, in *Flint Chips,* includes these specimens with other West Indian collars in English collections.

Mason seems to have adopted no theory regarding the use of the rings or collars, saying, "Whether they were the regalia of sacrificial victims,[1] of military heroes, of ecclesiastical worthies or of members of some privileged caste, who marched in double file through the streets of Porto Rican villages long since decayed, will perhaps forever remain a mystery."

Dr. A. Stahl considers the collars as *toison de piedra*—insignia of rank worn by chiefs or caciques in important festivals or assemblies. This explanation he applies more especially to the slender specimens, for the massive forms he regards as possibly implements of torture. It should be borne in mind that there is a general similarity in form of the massive oval and oblique ovate types which would imply a like use for both. Dr. Stahl declares that they "never have the form of serpents, as some have supposed."[2]

Sr. Agustin Navarette considers that these rings were neither idols nor parts of the same. He supposes that the massive forms were purely for the adornment of the cabins of the caciques, comparable with crowns which were worn by them. It is quite improbable that objects which cost so much time and labor were designed to be purely ornamental; and even granted that they were symbols of this kind, the question still remains, What is the meaning of their superficial decoration?

Sr. E. Neumann[3] regards it certain that the entire lifetime of a human being would be required for the polishing and ornamentation of a completed stone collar. He ascribes to a "Catholic priest," whose name is not given, the opinion that every cacique made a collar to be deposited over his grave on the day of his interment, in order to drive off the devil, but no proof is given to support this specula-

[1] Professor Mason had already said that there is no mention of human sacrifice by the natives.

[2] *Los Indios Borinqueños,* pp. 151–152.

[3] *Benefactores y Hombres Notables de Puerto Rico,* vol. II, p. li.

tion. Señor Neumann regards the idea, which he attributes to Señor Pi y Margal, that the tail of a serpent was cut on the surface of the collar, as a grave error, and seems not to have appreciated the true relation of the two parts which Acosta supposes were united to form the serpent image.

Regarding the use of these collars, Ober[1] says:

"Just what that use was no one can tell, the historians being silent on the subject, but I was told, when in Puerto Rico, by an old priest, that the Indians made them to be buried with them in their graves. One would spend a lifetime laboriously carving out this solid stone collar, that when he died it might be placed over his head, thus securely fastening him to his last resting place and defying the efforts of the devil to remove him."

The various interpretations of stone collars referred to in the preceding pages resolve themselves into two groups, one of which lays emphasis on the use of these objects as insignia or ornaments, the other on their symbolism. Those who have pointed out what they regard as their use have overlooked the fact that the decoration of the collar is highly conventionalized, an explanation of the significance of which they do not offer. We may accept the theory that some of them were worn on the body or around the neck, but the more important question of what they represent remains unanswered.

But there is a very serious objection to the acceptance of the theory that certain of these collars were worn as insignia, for some of them are too small, and the heaviest could be transported only a short distance even by a strong man.[2] Evidently they were not worn by chiefs as ornaments. The theory that they were in some instances worn by victims of sacrificial rites is weak, for there is evidence in historical records that sacrificial ceremonies, save of very harmless character, were not practised by the Antilleans.

It may be said in reply that here we have survivals of insignia or symbols no longer used, but preserving the form of those which were once employed; and it may also be urged that the heavy, massive forms of collars were unfinished, or that the massive and slender forms had different uses. While all these suggestions may have weight, it is remarkable that none of the early writers mention having seen them on the bodies of Indians. If they were used at the time of Las Casas, Roman Pane, Benzoni, and other early writers, it must have been in secret, which would show that they were ceremonial

[1] *Aborigines of the West Indies.* Proc. Amer. Antiquarian Soc., Worcester, Mass., 1894, p. 26.

[2] This objection to the theory that the stone collars were worn by men in dragging heavy objects, as logs or canoes, is a valid one.

objects. It is important to note that we have no early descriptions of the ceremonies of the Porto Rican aborigines, among whom these collars would have been the best known. No devoted Catholic priest observed and specially described the Borinqueños as Roman Pane, Morales, or Benzoni did the Haytians. What we know of the Porto Ricans of the sixteenth and seventeenth centuries is derived from the briefest possible references by Oviedo, Gomara, and others, who say that in their time they were similar to the inhabitants of Hispañola. The Porto Ricans may have used these collars in both secret and public exercises, but as no one is known to have specially described their ceremonies, there is no record of their purport or use.

All the available facts extant in regard to these collars point to their religious, or rather to their ceremonial, nature. We naturally regard objects made with so much care, and so highly symbolic in their decoration, as idols or as connected with worship; it is therefore more as such than as secular implements or ornaments that we can hope to decipher their meaning. As their strange form presents enigmatical possibilities, we naturally associate them with that other enigma in Porto Rican archeology, the tripointed stones.

The most suggestive interpretation yet offered is by Sr. J. J. Acosta, in his notes on Abbad Iñigo's great work,[1] that these stone collars were united with the tripointed stones and that both together form a serpent idol.

USE OF TRIPOINTED STONES

The use of the tripointed stones is as enigmatical as that of the stone collars or rings. Many authors have regarded them as idols, while others consider them as decorated mortars on which grain, seeds, or pigments were ground. In the latter interpretation the conoid prominence is regarded as a support which was embedded in the earth, thus imparting stability to the object, while the concave base, turned uppermost, served as a grinding surface.

Two objections may be urged to the theory that these triangular stones are mortars or grinding implements.[2] In the first place we can hardly suppose that one of these objects of the fourth type, which is only an inch in length, could have been very effective if used in

[1] *Historia Geografica, Civil y Natural de la Isla de San Juan Bautista de Puerto Rico; Nueva edicion anotada en la parte histórica y continuada en la estadística y económica;* Puerto Rico, 1866, p. 51.

[2] Many specimens of pestles with handles cut in the form of birds, quadrupeds, and human beings might be mentioned in this connection.

such a way; secondly, some of these specimens have all their sides as smooth as glass, showing no surface upon which anything could have been ground. In the third type the conoid prominence is highly ornamented, which would hardly be the case were this part buried in the ground, thus hiding the decorations from view. The conoid projection is not of proper shape for holding in the hand—a vital objection to the theory that the tripointed stones were used for rubbing.

But perhaps the strongest objection to the theory that the tripointed stones were used as mortars or rubbing stones is presented by a specimen in the Latimer collection which has a portion of the flat base covered by a superficial layer of resinous-like gum or varnish. There are other specimens which lead me to believe that several of these stones, like some of the wooden idols, were covered with a similar substance, the occurrence of which, still clinging to the base, shows the absurdity of regarding this as a polishing or grinding surface.

Mason does not commit himself to either the mortar or the idol theory. He says:

"The rough under-surface of the mammiform stones suggests the grinding of paint, incense, spice, or some other precious material, and the natives are said by the historians to have been fond of aromatic substances. Against this it may be urged that they are too costly for mortars; that some are hollowed underneath, some are flat, and some are convex; and that though very rough on the under side, the roughness seems to be that of an original pecking, excepting at the chin and knees of the Typhoean figure, where the stone is worn smooth. The furrows at the base of the mammæ seem to indicate the custom of lashing them to a staff as ensigns, or [their use] to dash out the brains of a victim or an enemy. There is no mention, however, so far as I am acquainted, of the natives performing human sacrifices. This lashing theory is strengthened by the fact that on some of the masks which closely resemble the mammiform stones there are cleat-like projections, evidently to be lashed to a handle. There are no grooves worn in the furrows by a lashing that I could discover. The bulging to the side of the mammæ, some to the right, others to the left, hints at their use in pairs."[1]

The theory that the tripointed stones are idols has many advocates, although some of the interpretations of the gods they represent are entirely speculative. Dr. Stahl,[2] in his chapter on religion, by

[1] Op. cit., p. 392.

[2] *Los Indios Borinqueños*, pp. 157–172. In this chapter Dr. Stahl makes no reference to Roman Pane and other writers who have given the most authoritative accounts of the religious concepts of the Haytians. There is little doubt that the Borinqueños resembled the Indians of Hispañola in their religious as well as in their secular customs.

limiting the term to a belief in a supreme beneficent being, or god, and a malignant being opposed to the same, finds that the Borinqueños were absolutely wanting in religious ideas ("*carecian en absoluto de ideas religiosas*"). He may be right in his criticism of Oviedo and other historians, that they read their own ethical ideas into their accounts of the West Indian religion, but he is certainly in error in concluding that there are no proofs, archeological or otherwise, to justify belief in the existence of any religious cult among the Borinquen Indians.

"The Antilles," writes Professor Mason, "are all of volcanic origin, as the material of our stone implements plainly shows. I am indebted to Professor S. F. Baird for the suggestion that, from the sea, the island of Porto Rico rises in an abrupt and symmetrical manner, highly suggestive of the mound in the mammiform stones, so that with the aid of a little imagination we may see in these objects the genius of Porto Rico in the figure of a man, a parrot, an alligator, an albatross, or some other animal precious to these regions where larger animals are not abundant, supporting the island on its back."

Earlier in this article I have referred to a few paragraphs by Professor Mason regarding the legend of Typhoeus killed by Jupiter and buried under Mount Etna. As he points out, "a similar myth may have been devised in various places to account for volcanic or mountainous phenomena."[1]

According to Sr. Agustin Navarette, Dr. Calixto Romero Cantero in his refutation of Dr. Stahl recognized in this tripointed figure the genius of evil weighed down by Borinquen, represented by the mountain Lucuo or Luquillo, and symbolized by the conoid prominence. He finds this theory of Cantero as objectional as that of Dr. Stahl that the Borinqueños had no religion, because there is no reason to believe that the Kiche god Cabraken was thought to be buried under Borinquen. Navarette[2] finds in this image a "cosmoteogonico" symbol conforming perfectly with a tradition given by Buret de Longchamps. "The cone," he says, "is chaos, from which, in the form of sunken rocks [*escollos*], arose Taraxtaïhetomos, the *principio creador,* perfectly defined, represented by the head, and Tepapa, the inert unformed matter, represented by the posterior part 'crossed by rays' [posterior appendages and feet!]." The universe was born from this "*principio creador*" and matter, as was likewise the firma-

[1] Op. cit., p. 380.

[2] *Estudios de Arqueologia de Puerto Rico. Resultados de una excursion cientifica.* Articles I–VIII, first printed in the periodical *El Noticio,* May, 1896; reprinted in *Aquila,* Ponce, April and May, 1904.

ment (*"bóveda que cubria la tierra"*); hence, he asserts, the base (of the tripointed stone) is scooped out in the form of an arch. "In a word," says Navarette, "this figure [tripointed image] is a semi [zemi], the unique Indo-Borinquen idol in which is symbolized the creator and inert matter on two sides of chaos which extends over the firmament [*bóveda del Universo*]."

My chief objection to Dr. Cantero's interpretation of the symbolism of the tripointed idols is that he elevates a "genius of evil" to a place it never occupied in the mind of the Antilleans. There is no satisfactory proof that the Borinquen Indians ever recognized a god of evil as we understand the conception. They no doubt believed in a great being whose power caused the terrible hurricanes which at times sweep over the island, and they possibly personated or deified this power as a great snake god. The early missionaries readily imagined that this deification of a mythic serpent was the analogue of their own personification of evil, but this interpretation was wholly their own, not that of the Indians.[1]

Navarette advances no adequate support for his statement that the conoid projection represents "chaos," and gives no authority for the statement that the Antilleans believed that the union of the *principio creador* and matter gave birth to the universe. I must also take issue with him in his statement that the "*semi*" is the unique "Indo-Borinquen" idol in which is symbolized this *principio creador,* because I believe he has mistaken the true meaning of the term *zemi.* Although the great Sky God may have been called a *semi, chemi, cemi,* or *zemi,* the word probably means not one but many subordinate supernatural beings, as elsewhere pointed out. Tutelary gods are called *zemis,* in which case the word has simply the same meaning as "clan totem." These tripointed Borinquen idols have different forms, representing reptiles, birds, and human beings, a difference which indicates the improbability that they represent one great supernatural being or creator (*"principio creador"*).

The comparison of the head of a tripointed stone with a "creator" and the feet with "matter," the conical projection representing "chaos," has no historical evidence to support it, while the recognition of the arch of the universe in the curved base is equally unsupported. The second and third types of tripointed idols show the absurdity of the entire theory of the nature of the tripointed stones

[1] The word *mabouya,* used by the Antilleans as a name of some of their gods, as well as of images of the same, is probably derived from *ma,* "great," and *boya,* "snake." The same word *boya* (English boa) likewise gave the name *boii,* "sorcerers," to some of their priestly orders.

as expounded by Navarette. Chaos in the last type mentioned has evidently been swallowed by a huge monster whose mouth takes its place.

This likeness of the tripointed stone to a god or genius of Porto Rico buried under a superposed mountain represented by the conoid projection is marked in the first type, less evident in the second, and wholly absent in the third. In the fourth all semblance of this kind has disappeared. All theories which compare the conoid prominence to a mountain, to chaos, or the like, fail when we apply them to all types of tripointed stones, and do not account for the different kinds of heads found in the first type.

The tripointed stones represent several different kinds of supernatural beings, anthropomorphic and zoömorphic. The Borinquen Indians, like those of Hayti, recognized one great supreme god, but he was not a creator. Roman Pane distinctly states that this god had a mother whose five names he has mentioned.

I regard the tripointed stones as clan idols or images of tutelary totems—true *zemis* in the sense in which the term is employed by the majority of early writers. The differences in their forms denote different conceptions of the zemi in different clans. Each cacique, no doubt, had one or more of these images, representing his clan zemi and such others as he had inherited or otherwise obtained. I regard them as the idols of which Roman Pane wrote: " Each one [Indian] worships the idols of special forms called zemis, which he keeps in his own house."

ELBOW STONES

There is another group of stone objects, also found in Porto Rico, which, like those we have considered, are likewise problematical, yet which may shed some light on the relationship of stone collars and tripointed idols. I refer to the objects which, from their shape, may be called " elbow stones,"[1] several of which occur in different collections. Some of these stones closely resemble fractured or broken collars of the slender ovate type, and often have parts which may be compared to boss, panel, and panel margin of entire collars. The finish of the extremities of the elbow stones indicates that they are not broken collars but are of another type with some similarities to them. Their significance in relation to the theory that tripointed stones and collars were the two component parts of a single object lies in the fact that a head resembling a mask-like tripointed stone is

[1] This designation, here used for the first time, is a convenient one to apply to this group of stone objects peculiar to Porto Rico and Santo Domingo. The group includes many aberrant forms of elbow shape, the exact use of which is problematical. One of these is illustrated by Mason in his figure 195.

sometimes cut on the part of the elbow stone corresponding to the undecorated panel of the stone collar. It is held that in these elbow stones the face is cut on the undecorated panel instead of being fastended to it as in the case of collar stones.

Two examples of these elbow stones with faces may be mentioned to illustrate their significance in this connection; one (pl. XXVII) is figured by Mason, the other by Pinart. Professor Mason is doubtful whether the specimen which he illustrates[1] is a broken collar adapted to a secondary use or belongs to a distinct class. Something could be said in support of the former supposition, but there are similar specimens where resemblance to a broken collar is less apparent. The elbow stone figured by Pinart[2] has a human face represented on that part of its surface which corresponds to the undecorated panel of a collar. In his description of this object, Pinart writes: "L'ornementation des premiers varie assez, bien que le principal sujet de l'ornementation se trouve toujours à la partie oú la collier présente un renflement. Cette ornementation représente dans le cas présente une figure humaine: nous avons recontré également la grenouille, la chouette, etc., etc."

The figures of the above mentioned objects resemble each other so far as the position of the face is concerned, the ears and fillet over the forehead being in both instances well represented. Pinart's specimen has the arms, or extensions comparable with that portion of the body of a collar, longer than those figured by Mason, and are beaded at the extremity, a feature not represented in any stone collar. Similar beading is found on an elbow stone figured by Mason[3] in which no face is cut on the panel region, and the same feature occurs in a rude elbow stone which I collected at Ponce, Porto Rico. In the Mason specimen one arm is perforated as in the elbow stone with a face which Mason describes and figures. This perforation and beading may indicate places for attachment of strings by which the object was suspended or lashed to some other object.

One of the best of these elbow stones has a complete figure of a human being cut in relief on the panel corresponding to that bearing the face in the Mason and Pinart specimens. This object has no resemblance to a broken collar, although it belongs to the same type as that above mentioned. Like Pinart's specimen, the extremities of the arms or extensions are beaded, a feature not found in the Mason elbow stone on which a face is represented. This elbow stone has a complete human figure carved in relief on its panel and is figured in

[1] Op. cit., figure 58 (plate XXVII of this paper).

[2] Op. cit., pl. 10, figure 3.

[3] Op. cit., figure 195.

Neumann's work, above referred to, which is a reprint of a figure in the Spanish periodical *La Ilustración Española y Americana.*

I regard these elbow stones as a distinct type, having a morphological likeness to the pointed pole, or boss and neighboring parts, of an oblique oval collar. Their use and meaning are enigmatical.

ACOSTA'S SERPENT THEORY OF STONE COLLARS

I have reserved a consideration of this theory until the end because it differs radically from all others, and because a consideration of it demands a knowledge of the forms of the three groups of objects herein considered—stone collars, tripointed idols, and elbow stones. Señor Acosta was familiar with the Latimer collection before it came to this country, and also with another, now scattered, which formerly existed in the Museo de Artilleria at San Juan, Porto Rico. He writes thus of the stone rings and tripointed figures:[1]

"Todos estos ídolos, aunque varían en el tamaño y en la clase de piedra en que están labrados, pues unas son cuarzosas y otras calizas, ofrecen generalmente la misma disposicion y figura. Consta cada uno de dos partes distintas y separadas, pero que se adaptan perfectamente entre sí—1ª Un anillo elipsoidal, en cuya superficie externa aparece tallada la cola de una serpiente.—2ª Una pieza maciza cuya base, por donde se adapta al anillo, es plana y de figura elipsoidal, y cuya parte superior termina en forma de cono: hácia un extremo del eje mayor de la base hay varias molduras caprichosas, y en el extremo opuesto una cara humana. Unidas las dos partes del idolo, semeja el todo una serpiente enroscada con fisonomía humana."

The following translation has been made of Acosta's description:

"All these idols, although they vary in size and in the kind of stone of which they are made, for some are of quartz[2] and others of limestone,[3] have the same general proportions and form. Each one is composed of two distinct and separate parts which fit perfectly together: 1st, An ellipsoidal ring, on the external surface of which is cut a serpent's tail. 2nd, A massive piece, the base of which when it fits the ring, is flat and of ellipsoid shape, while the upper part terminates in a cone; toward the end of the greater axis of the base there are various capricious moldings, and at the opposite end a human face. When the two component parts of the idol are united, the whole resembles a coiled serpent with human physiognomy."

One or two other authors speak of these collars as "snake stones," but as no additional grounds for this identification are given, they apparently accepted Acosta's conclusion.

[1] *Historia Geográfica, Civil y Natural de la Isla de San Juan Bautista de Puerto Rico,* por Fray Iñigo Abbad y Lasierra; Puerto Rico, 1866, p. 51.

[2] Diorite.

[3] Marble.

Several significant facts appear to support the theory that another object was once attached to the undecorated panel of the stone collar:

(1) This panel is left rough and is never decorated; its plane of convexity is approximately the same as the concave curvature of the base of the tripointed stones. It has a pit or depression in its center, and the base of the tripointed stone sometimes has a similar pit in the same relative position. On this theory the object of these pits would be to insure a firmer attachment of the two objects. The use and function of both collars and tripointed stones are enigmatical, but their geographical distribution is identical, and the abundance or rarity of the two are in the same relative proportion.

(2) Some of the elbow stones appear feebly to support the Acosta theory in this way. The elbow stone of the Latimer collection resembles closely that part of a broken collar which includes the boss and one panel. An examination of this panel shows that it conforms in relative position to the undecorated panel of a collar. A human face is carved in relief on this panel in the place at which the tripointed stone would have been cemented to the collar. The elbow stone figured by Pinart has a similar face cut on its panel. On the supposition that there is a likeness in form between stone collars and elbow stones, this fact may be significant.

It may be mentioned that since Acosta wrote the lines above quoted a larger number of these tripointed stones than he saw have been examined, and that from increased knowledge of them minor corrections of his account are possible. For instance, what he calls "capricious moldings" toward the end of the greater axis are undoubtedly legs or appendages, while the "human face" at the other end of the greater axis is now known to be sometimes replaced by the head of a bird, lizard, or other animal. Acosta apparently was familiar with but one kind of tripointed stone, or that called in this article the first type.

As objections to Acosta's theory of the former union of stone collars and tripointed stones, the following may be urged:

(1) That in the available accounts of the religion of the natives of the West Indies, no mention is made of a serpent cult, and that no record contemporary with the aborigines has given the snake a prominent place in myth or ritual. It is recorded, however, that two wooden images of serpents stood at the entrance to a house on one of the islands visited by the Spaniards, and I have already referred to a wooden serpent idol in Puerto Plata, which is one of the best known examples of aboriginal West Indian wood carving. These show conclusively that the Antilleans carved images of snakes in wood, hence

the implication is that these images were used as idols and played a conspicuous role in their worship.

(2) Another fact, quoted as opposed to the Acosta interpretation, is that no tripointed stone has yet been found to fit closely to the undecorated panel of any collar, nor have these objects ever been found united or in close proximity.

(3) A glance shows that some of these tripointed stones bear birds' heads and representations of wings; others have snouts, like reptiles; and in many, grotesque human faces appear to have been represented, but not a single tripointed stone resembles a serpent's head. To meet this objection it may be urged that primitive art is rarely realistic, but more often is highly conventionalized.

(4) The presence of legs on a majority of the tripointed stones of all types is fatal to the theory that these images represent heads of apodal serpents. If we avoid this objection by limiting the theory to those tripointed stones which have no legs carved in relief or otherwise, we are obliged to discriminate, for what is true of one ought to hold good for the others.

(5) Another objection which may be raised to the Acosta theory is that representations of heads, realistic or symbolic, or both, are cut on the decorated panel border of several collars. Although these carvings are sometimes highly conventionalized, their presence would imply two heads to the same body if a tripointed stone also representing a head were attached to the undecorated panel.

The weight of evidence thus seems to be against the Acosta theory that the tripointed stones were attached to stone collars for the purpose of completing idols of which he supposed the two objects formed the component parts.

The theory that collars and tripointed stones stand in the relationship of female and male symbols, and were used in ceremonies to insure germination or fructification, is not improbable, but like other theories it lacks decisive facts for its support.

In closing this article I find, like those who have previously studied the subject, that what is needed to solve this problem of the stone collars and tripointed idols, are more facts regarding their differences in form. Especially do we need observations on the association of these objects with other aboriginal specimens. Are they found with remnants of human skeletons or with other mortuary remains, and, if so, is their association of such a nature that they suggest idols or religious paraphernalia? It is not too late to answer these questions satisfactorily if investigations are continued in parts of Porto Rico hitherto unknown to the archeologist.

a

b

MASSIVE COLLARS

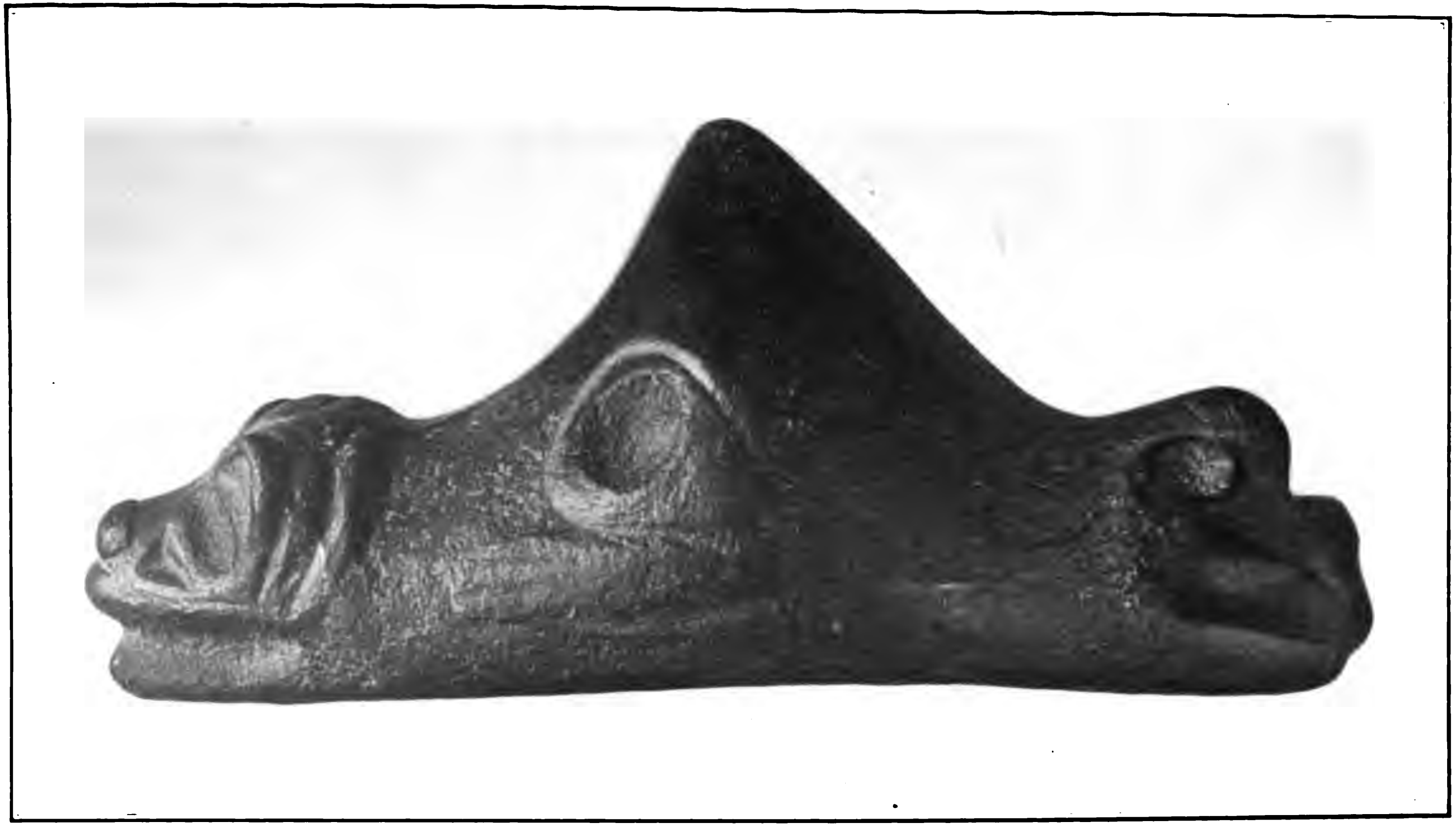
a, Diameter 17½ inches (No. 220,600). *b*, Diameter 18 inches (No. 201,495).

a

b

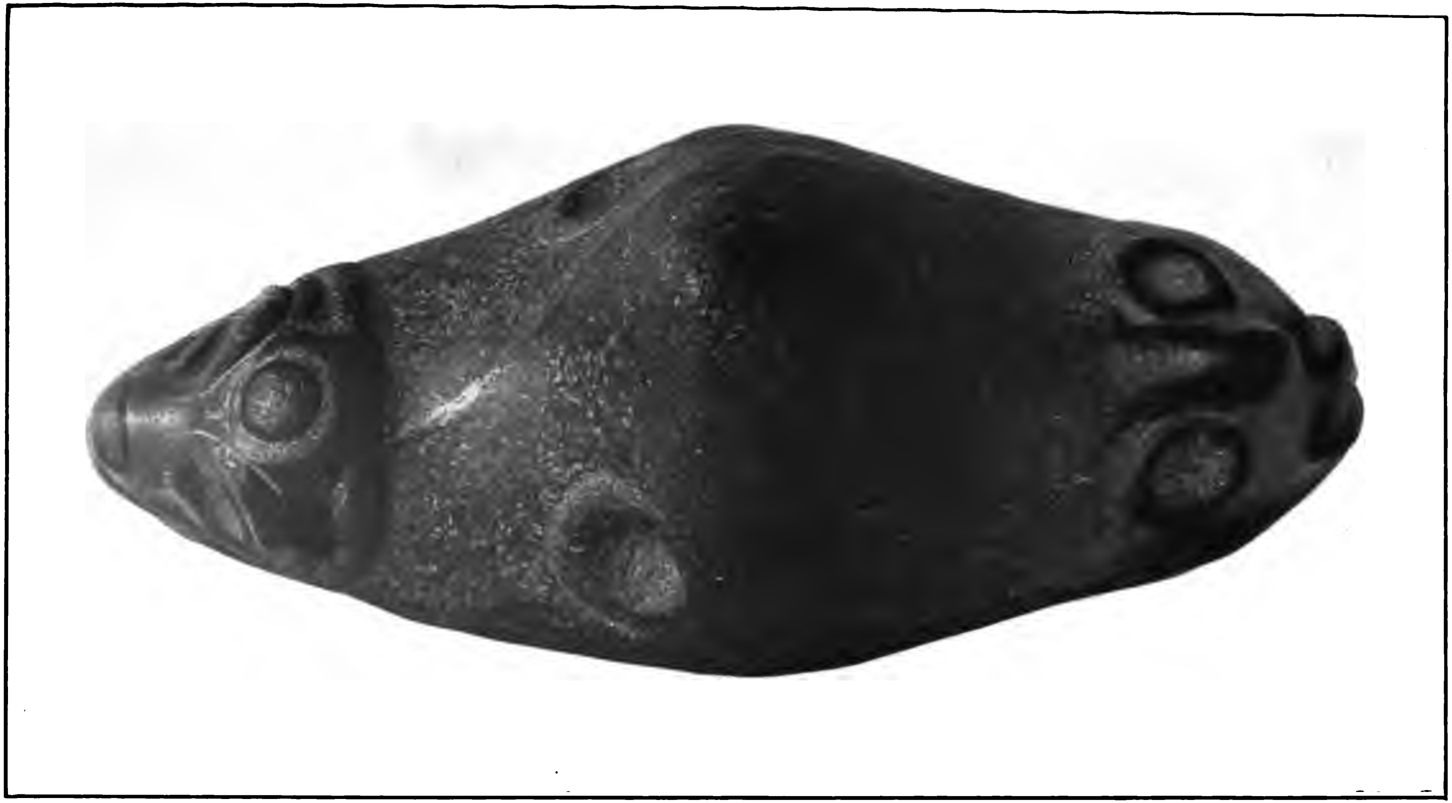
SLENDER COLLARS

a, Diameter 15½ inches (No. 231,397). *b*, Diameter 17 inches (No. 231,396).



TRIPOINTED STONE OF THE FIRST TYPE (SIDE VIEW)

Length 11½ inches (No. 231,142).



TRIPOINTED STONE OF THE FIRST TYPE (TOP VIEW)

Length 11½ inches (No. 231,142).

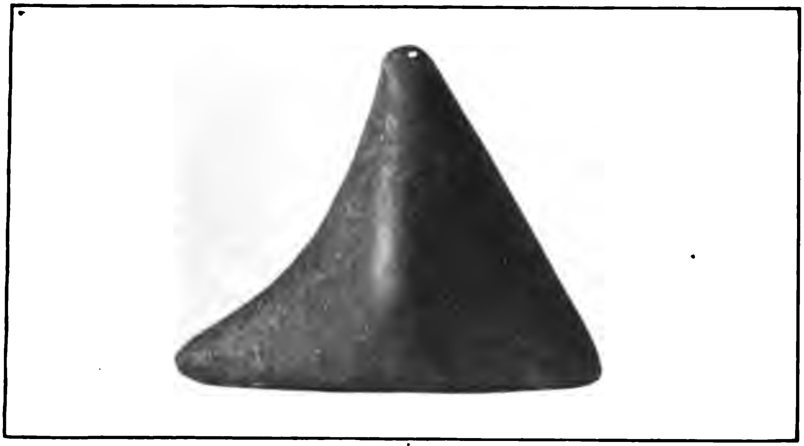
TRIPOINTED STONES OF THE SECOND TYPE

Side view, length 4 inches; rear view, height 3 inches. (No. 220,621.)

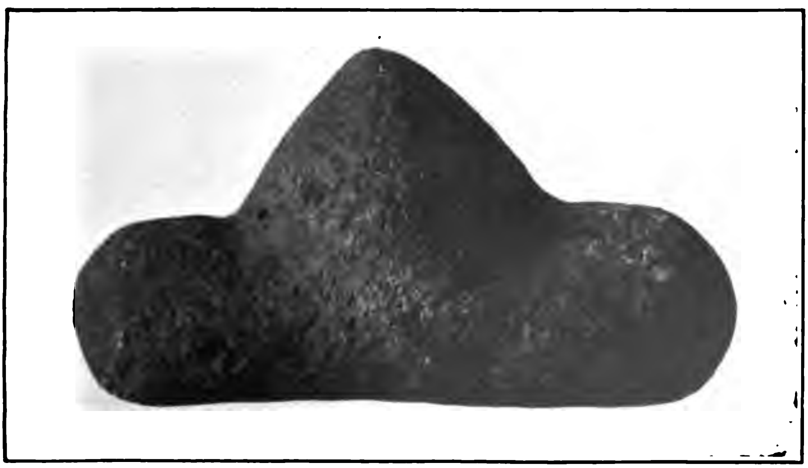
TRIPOINTED STONES OF THE THIRD TYPE

Length 4¼ inches (No. 231,411).

a



b



c

TRIPOINTED STONES OF THE FOURTH TYPE

a, Length 3⅛ inches (No. 220,630). *b*, Length 4⅝ inches (No. 220,619). *c*, Length 8 inches (No. 16,991).

Side view, width 7¼ inches.

Face view, length 7¼ inches.

ELBOW STONES

NOTES ON THE GENUS SONORELLA, WITH DESCRIPTIONS OF NEW SPECIES

By PAUL BARTSCH

In the *Proceedings* of the Academy of Natural Sciences of Philadelphia for 1900 [1901], pp. 556–560, Dr. H. A. Pilsbry defined the genus *Sonorella* and referred to it the following species: *Epiphragmophora hachitana* Dall, *Helix* (*Arionta*) *magdalenensis* Stearns, *Helix* (*Arionta*) *coloradoënsis* Stearns, *Epiphragmophora arizonensis* Dall, *Helix rowelli* Newcomb, *Helix* (*Arionta*) *carpenteri* Newcomb variety *indioensis* Yates, *Helix lohrii* Gabb, and probably *Helix carpenteri* Newcomb.[1] Since then *Sonorella granulatissima* Pilsbry and *S. wolcottiana* Bartsch have been described.

The shells of the various species of *Sonorella* bear close resemblance to each other, with perhaps the exception of *S. dalli* n. sp. and *S. lohrii* Gabb. The ephebic portion of all is polished, marked by lines of growth and in some of the species by raised papillæ—never by incised spiral lines. A careful examination of the nuclear whorls shows variations along several lines, and these variations may be utilized in grouping the species. The first or nepionic stage is always small, embracing only a fraction of a turn; it appears to be similar in all the species, varying only slightly in extent and in the strength of the transverse wrinkles which constitute its sole sculpture. It is in the second or neanic stage that we find variations. These may be defined as follows:

I.—Group of S. wolcottiana

(Plate XXVIII)

In this group there are many narrow, low, raised lines or wrinkles which coincide with the lines of growth; and in addition to these there are numerous prominent, distinct, elongate-oval papillæ, the long axis of which is at a right angle to the lines of growth. These papillæ are so arranged that alternate series fall in the same spiral line, i. e., the papillæ of each succeeding series point toward the middle of the space between the papillæ of the series preceding, the complete effect being interrupted papillose lines which extend from the summit of the whorls obliquely forward and downward toward the suture.

[1] *Epiphragmophora carpenteri* Newcomb is not a Sonorella; incised spiral lines are never present in this genus.

II.—Group of S. hachitana

(PLATE XXIX)

This group is characterized by having the neanic portion marked by wrinkled growth-lines, over which pass many slender, more or less continuous, irregular, wavy threads which extend from the summit of the whorls obliquely downward and forward to the suture; in addition to these a second set of raised lines, somewhat less strong and distinct, and equally irregular, pass in an opposite direction, i. e., obliquely downward and backward from the summit to the suture. These two sets of lines frequently meet, forming acute angles at their junction. The general effect might be termed subareolate.

III.—Group of S. magdalenensis

In this group the neanic portion is found to be marked by one set of fine, distinct, raised lines which extend from the summit of the whorls in a very oblique curve downward and backward to the periphery; while another set of the same character extends in a very oblique curve upward and backward to the periphery, where they meet the first set, forming acute angles. These raised lines are quite regularly spaced, and the spaces between them appear minutely pitted.

IV.—Group of S. fisheri

(PLATE XXX)

In this group the transverse wrinkles or lines of growth are stronger than in the preceding groups. No raised lines are present; only here and there do we find traces of a few distant, irregularly scattered, low, oval, raised papillæ, the long axis of which is at right angles to the lines of growth.

GROUP OF *S. wolcottiana*

SONORELLA WOLCOTTIANA Bartsch

(PLATE XXXI, FIGURE 4)

Sonorella walcottiana BARTSCH, Proc. Biol. Soc. Washington, vol. XVI, pp. 103–104, 1903. (Typographical error.)

Sonorella wolcottiana BARTSCH, Proc. Biol. Soc. Washington, vol. XVII, p. 101, 1904.

S. wolcottiana B. is the largest member of this group. The type (No. 170,007, U. S. Nat. Museum) measures: maj. lat. 23.5 mm., min. lat. 18.5 mm., alt. 15.5 mm.; aperture: maj. lat. 14 mm., alt. 12.7 mm. The fact that the broadly expanded and decidedly reflected columella almost conceals the umbilicus will readily differentiate it from the next two species, which are rather openly umbilicated. The type locality is Palm Springs, Riverside county, California; other localities are Palm valley and vicinity, Colorado desert, San Diego county, California.

SONORELLA INDIOENSIS (Yates)

(PLATE XXXIII, FIGURE 1)

Helix (*Arionta*) *carpenteri* NEWC. var. *indioensis* YATES, Nautilus, vol. IV, p. 63, 1890.

Arionta var. *indioensis* DALL, Proc. U. S. Nat. Museum, vol. XIX, p. 337, 1896.

Epiphragmophora indioensis PILSBRY, Man. Conch., vol. IX, p. 199, 1894.

Epiphragmophora indioensis PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Sonorella indioensis PILSBRY, Proc. Acad. Nat. Sci. Phil'a for 1900, p. 506, 1901.

The type is said to measure: maj. lat. 18 mm., alt. 12 mm.; it comes from Indio, Riverside county, California. *S. indioensis* is larger but more depressed than the next species. A specimen, here figured, in the U. S. National Museum collection (No. 108,530), from the type locality, measures: maj. lat. 17.8 mm., min. lat. 14.3 mm., alt. 10.5 mm.; aperture: maj. lat. 9.9 mm., alt. 8.5 mm.; umbilicus about 1.8 mm.

SONORELLA COLORADOËNSIS (Stearns)

(PLATE XXXII, FIGURE 3)

Helix (*Arionta*) *coloradoënsis* STEARNS, Proc. U. S. Nat. Museum, vol. XIII, p. 226, pl. XV, figs. 6, 8, 12, [not 7], 1890.

Helix coloradoensis PILSBRY, Man. Conch., vol. VIII, p. 225, pl. 56, figs. 1, 2, 3, 1893.

Epiphragmophora coloradoensis PILSBRY, Man. Conch., vol. IX, p. 199, 1894.

Epiphragmophora (*Arionta*) *coloradoensis* DALL, Proc. U. S. Nat. Museum, vol. XIX, pp. 340–341, 1896.

Epiphragmophora coloradoensis PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Sonorella coloradoensis PILSBRY, Proc. Acad. Nat. Sci. Phil'a for 1900, p. 560, 1901.

Sonorella coloradoënsis Stearns is the smallest member of this group. The type (No. 104,100 U. S. Nat. Museum) measures: maj. lat. 16.4 mm., min. lat. 13.8 mm., alt. 10 mm.; aperture: maj. lat. 8.5 mm, alt. 8.2 mm., umbilicus about 1.8 mm. The shell of this species is more elevated than in *S. indioensis* Yates, and the aperture is more circular in outline. The type locality is Grand Cañon of the Colorado, opposite the Kaibab plateau, altitude 3,500 ft. Pilsbry and Johnson (loc. cit.) also cite this species from Inyo and San Diego counties, California, but the specimens from these two localities should be reëxamined as it seems probable that the one from Inyo county may belong to *S. baileyi* B. or *S. fisheri* B., while those from San Diego county may belong to *S. indioensis* Yates.

GROUP OF *S. hachitana*

SONORELLA ASHMUNI new species

(PLATE XXXI, FIGURE 5)

Shell like *S. hachitana* Dall, but larger in every way. General coloration light isabelline above and whitish below; a broad chestnut band, bordered on each side by a light zone, encircles the whorls somewhat above the periphery and may be seen above the suture on all the ephebic whorls; the band gradually diminishes in breadth from the aperture toward the apex. The nepionic stage embraces the first half turn, is somewhat flattened, and slopes outward; it is marked by a few transverse wrinkles and passes without distinct separation into the neanic stage, which is described in the definition of the group. The neanic portion consists of one and one-quarter turns; its termination is marked by several strong, transverse wrinkles. The ephebic stage consists of three and one-eighth moderately rounded, polished whorls which are marked by numerous lines of growth and here and there by a few obsolete, very distantly and irregularly scattered, rounded papillæ. Last whorl considerably deflected at the aperture, which is large and oblique and has the outer edge expanded and somewhat reflected; columella broadly expanded at base, reflected only slightly over the umbilicus, which is moderately large and open to the very apex; parietal wall covered by a thin callus. The type (No. 151,450, U. S. Nat. Museum) was presented by the Rev. E. H. Ashmun, after whom the species is named. It was collected at Richinbar, south of Prescott, Arizona, at an altitude of 3,500 ft. It measures: maj. lat. 28.2 mm., min. lat. 23.2 mm., alt. 16.9 mm.; aperture: maj. lat. 15.2 mm., alt. 13 mm.; width of umbilicus, about 4 mm.

Another lot (No. 152,125, U. S. Nat. Museum), collected at Jerome, Arizona, was received from the same gentleman.

SONORELLA HACHITANA Dall

(PLATE XXXI, FIGURE 2)

Epiphragmophora hachitana (in part) DALL, Proc. U. S. Nat. Mus., vol. XVIII, p. 2, 1895.

Epiphragmophora hachitana (in part) DALL, Proc. U. S. Nat. Mus., vol. XIX, pp. 338–339 [not pl. xxxi, figs. 7, 10, which is *S. dalli* Bartsch].

Epiphragmophora hachitana (in part) PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Sonorella hachitana PILSBRY, Proc. Acad. Nat. Sci. Phil'a for 1900, pp. 556–560, 1901.

The type (No. 130,004, U. S. Nat. Museum) and many other specimens were collected by Major Edgar A. Mearns, U. S. A., in the Hachita Grande mountains, southwestern Grant county, New Mexico, at an altitude of 8,271 ft. The type measures: maj. lat. 23.7 mm., min. lat. 19.5 mm., alt. 13.4 mm.; aperture: maj. lat. 12.1 mm., alt. 10 mm.; umbilicus about 4 mm.

Additional localities represented by specimens in the U. S. Nat. Museum are: (No. 130,005) On top of two peaks near Carrizollilo Springs, at the Mexican boundary, Grant county, New Mexico. (No. 126,596) Doubtful cañon, Peloncillo mountains, southwestern Grant county, New Mexico. (No. 151,445) Chiricahua mountains, northwestern Cochise county, Arizona; altitude 3,500 ft. (No. 105,385) Santa Rita mountains, Pima county, Arizona. (No. 130,-006) Black mountains, right bank of San Bernardino river, 12 miles south of boundary monument 77, northern Mexico.

SONORELLA NELSONI new species

(PLATE XXXI, FIGURE 3)

Shell similar to *S. hachitana* Dall, but larger and more depressed, with the aperture larger and more circular in outline. General coloration (our specimens appear to be bleached) flesh color, with a moderately broad light-chestnut band bordered by a lighter zone on each side, encircling the whorls a little above the periphery, showing as a narrow band above the sutures. The nepionic stage consists of about one-half of a turn and is rather strongly and closely transversely wrinkled. The neanic stage embraces about one and one-half volutions and is typically sculptured, the lines of growth appearing a little stronger and more undulated than in *S. hachitana*. The ephebic stage consists of two and one-half moderately rounded whorls, the last of which is deflected somewhat below the rounded periphery at the aperture. Base of the whorls more convex than the portion between the sutures. The entire surface of the ephebic stage is marked by many incremental lines and a few rather narrow, elongate, irregularly spaced, low subobsolete papillæ which are better defined on the early portion than the last where they appear to be entirely absent. Aperture large, subcircular, with the lip expanded but not reflected; columella moderately expanded at base and slightly reflected, but not obscuring the umbilicus, which appears open to the apex. The type and several additional specimens (No. 174,934, U. S. Nat. Museum) were collected by Messrs. Nelson and Goldman in the mountains near Lake Santa Maria, Chihuahua, Mexico. The type measures: maj. lat. 25.5 mm., min. lat. 20.3 mm., alt. 13.4 mm.; aperture: maj. lat. 12.8 mm., alt. 11.1 mm.; umbilicus about 4 mm.

Sonorella nelsoni resembles *S. hachitana* in general shape, but is more depressed and has a much larger aperture, in which latter respect it approaches *S. ashmuni.*

SONORELLA GOLDMANI new species

(PLATE XXXII, FIGURE 6)

Shell decidedly elevated, with the last whorl very much deflected. General coloration: light isabelline above, white below, with a moderately broad, light-chestnut band, bordered by a lighter zone on each side, encircling the whorls a little above the periphery. This band is completely exposed above the suture on all the ephebic whorls. The nepionic stage is extremely small, embracing less than one-fourth of a turn, and it appears almost smooth. The neanic stage consists of one and one-half volutions bearing the characteristic sculpture of the group, but very feebly developed. The ephebic stage embraces three and three-fourths well rounded whorls, the summit of each of which falls a little below the dark band. This is particularly true of the last two and one-half volutions where the light-colored zone below the dark band is exposed. The periphery and the base are well rounded; the latter is of about the same convexity as the space between the sutures. The entire ephebic portion is marked by incremental lines only. The whole last whorl is deflected, but more rapidly at the aperture, which is small, expanded, and slightly reflected; columella expanded at base and reflected, its margin scarcely encroaching upon the umbilicus; parietal wall covered by a rather strong callus; umbilicus open to the summit. The type (No. 174-933, U. S. Nat. Museum) and another specimen were collected by Messrs. Nelson and Goldman in the mountains near Lake Santa Maria, Chihuahua, northern Mexico. The type measures: maj. lat. 22.5 mm., min. lat. 19.4 mm., alt. 14.9 mm.; aperture: maj. lat. 11 mm., alt. 9.4 mm.; umbilicus about 3 mm.

Sonorella goldmani differs from all the other species in its proportionately greater elevation and its much deflected last whorl.

SONORELLA MERRILLI new species

(PLATE XXXII, FIGURE 5)

Epiphragmophora hachitana (in part) DALL, Proc. U. S. Nat. Museum, vol. XIX, p. 340, 1896.

Epiphragmophora hachitana (in part) PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Shell resembling *S. arizonensis* in shape, but larger, with proportionately smaller aperture. General coloration: pale flesh color; a narrow pale-chestnut band encircles the whorls a little above the periphery, but is visible above the suture only in the last one and one-half turns. The nepionic stage embraces about half a volution, is somewhat flattened, slopes outward, and is marked by rather coarse, wavy, transverse wrinkles; there is no abrupt demarcation between this stage and the neanic. The neanic portion consists of one and a fourth turns and is marked by rather strong incremental lines upon which is placed the rather feebly developed sculpture characteristic of the section. The ephebic portion consists of three and one-half moderately rounded volutions which are marked by numerous incremental lines and by very dense, exceedingly minute granulations, both on the upper and the lower surface. The last whorl is decidedly deflected at the aperture, which is of medium size, subcircular, only slightly expanded, and not reflected. Columella moderately broad and expanded at base, not reflected over the rather wide umbilicus, which appears open to the apex. The type (No. 125,260, U. S. Nat. Museum was collected by Dr. G. P. Merrill below San Quentin, Lower California. It measures: maj. lat. 22 mm., min. lat. 18 mm., alt. 12.5 mm.; aperture: maj. lat. 10.5 mm., alt. 9.5 mm.; umbilicus about 4 mm.

SONORELLA GRANULATISSIMA Pilsbry

(PLATE XXXII, FIGURE 4)

Sonorella granulatissima PILSBRY, Nautilus, vol. XVI, p. 32, 1902.

Sonorella granulatissima Pilsbry resembles *S. hachitana* in form but is smaller in every way, with a decidedly smaller umbilicus, and densely, evenly granulose. The type locality is Huachuca mountains, Arizona. The measurements given by Dr. Pilsbry are: alt. 10 mm., diam. 19 mm.; oblique alt.: aperture 9.7 mm., width 11 mm. Another specimen is said to measure: alt. 9.8 mm., diam. 18 mm.; oblique alt.: aperture 8.5 mm., width 9.8 mm.

The U. S. National Museum has two lots (Nos. 130,007, alt. 9,382 ft., and 130,008) from Huachuca mountains, and one (No. 124,-479 *a*) from Tucson, Arizona.

SONORELLA DALLI new species

(PLATE XXXI, FIGURE 1)

Epiphragmophora hachitana (in part) DALL, Proc. U. S. Nat. Museum, vol. XVIII, p. 2, 1895.

Epiphragmophora hachitana (in part) DALL, Proc. U. S. Nat. Museum, vol. XIX, pp. 339-340, pl. xxxi, figs. 7, 10, 1896.

Epiphragmophora hachitana (in part) PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Shell large, depressed, light-brown horn color above, lighter below, with a broad brown band bordered on each side by a lighter zone encircling the whorls a little above the periphery. This band can be seen on all the ephebic whorls above the suture. Nepionic portion a little less than half a whorl, somewhat flattened and outward-sloping, marked by a few moderately strong transverse wrinkles. The neanic stage embraces one and one-half turns; the incremental lines are moderately well marked, very wavy, and closely placed; the characteristic supersculpture of this part is extremely fine, with the lines placed so closely that the complete effect at first appears granular. The ephebic stage consists of three depressed, moderately rounded whorls, which are less convex above than below and are marked by many strong incremental lines and numerous microscopic granulations. The last whorl is considerably deflected at the aperture and shows a tendency to become angular at the periphery. The aperture is moderately large, subcircular, very oblique, expanded, and slightly reflected; columella moderately expanded at base and scarcely reflected over the rather large umbilicus, which appears open to the summit. The type (No. 130,009, U. S. Nat. Museum) and five additional specimens were collected by Maj. E. A. Mearns, U. S. A., at Tanners cañon, Huachuca mountains, Arizona. The type measures: maj. lat. 26.5 mm., min. lat. 21.1 mm., alt. 12 mm.; aperture: maj. lat. 11.8 mm., alt. 10.5 mm.; umbilicus about 4 mm. Two additional lots (Nos. 129,136, 125,598) come from the same mountains, the latter from Fort Huachuca.

SONORELLA MEARNSI new species

(PLATE XXXII, FIGURE 2)

Epiphragmophora magdalenensis (in part) DALL, Proc. U. S. Nat. Museum, vol. XIX, p. 339, 1897.

Shell similar to *S. dalli* in shape and coloring, but only two-thirds as large. The nepionic stage consists of about one-half of a volution, is moderately rounded, and is crossed by a few prominent transverse wrinkles. The neanic stage embraces one and one-fourth turns, and is marked by irregular, fairly strong incremental lines and the characteristic sculpture of the section, which is extremely fine and closely placed as in *S. dalli*. Ephebic whorls two and one-third rather depressed, moderately rounded, considerably more convex below than above, with the periphery of the last whorl somewhat subangulate. The entire surface of this portion is marked by quite prominent incremental lines and numerous very fine and closely placed granulations. The last whorl is considerably deflected at the aperture, which is very oblique, suboval, and but slightly expanded. Columella rather broad, expanded at base and partly reflected over the rather narrow umbilicus. The type (No. 130,003, U. S. Nat. Museum) and three additional specimens were collected by Major E. A. Mearns, U. S. A., in the San José mountains, Sonora, Mexico, about four miles south of the Arizona boundary and a few miles east of San Pedro river. The type measures: maj. lat. 16 mm., min. lat. 13 mm., alt. 8 mm.; aperture: maj. lat. 8.4 min., alt. 7.3 mm.; umbilicus about 2 mm.

SONORELLA BAILEYI new species

(PLATE XXXIII, FIGURE 4)

Epiphragmophora magdalenensis (in part) DALL, Proc. U. S. Nat. Museum, vol. XIX, p. 339.

Epiphragmophora magdalenensis (in part) PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

This is the smallest member of the group, approaching *S. fisheri* in size. Shell rather depressed; general coloration light flesh color with a moderately broad pale brown band encircling the whorls a little above the periphery. This band is only partly visible above the suture, above the last volution. The nepionic stage is rather small, embracing only about one-fourth of a turn; it is sparingly marked with transverse wrinkles. The neanic portion consists of one and one-half volutions, which are ornamented by incremental lines upon which are placed the characteristic sculpture of the section, the lines seeming to consist of fused attenuated papillæ. This species therefore shows a tendency toward the group of *S. wolcottiana*. Ephebic whorls a little more than three, moderately rounded, less so between the sutures than on the base, marked by many incremental lines, and somewhat distant regularly disposed rows of small oval papillæ which have an arrangement similar to that found on the neanic portion of the *S. wolcottiana* group, i. e., alternate series fall in the same spiral plane and this lends the whorl the appearance of being crossed by interrupted curved lines of papillæ passing from the summit of the whorls very obliquely forward and downward to the suture. These papillæ are best developed between the sutures on the early whorls; they appear to become gradually lost on the last half of the last whorl. The last whorl is moderately deflected at the aperture, which is of medium size, very oblique, almost circular and scarcely expanded. Columella only slightly expanded at base; parietal wall covered by a thin callus; umbilicus moderately wide and open to the apex. The type (No. 123,907, U. S. Nat. Museum) was collected by Mr. Vernon Bailey on the Death Valley expedition at Resting springs, Inyo county, California, among rocks on a dry hill 900 ft. above the spring. The type measures: maj. lat. 15.1 mm., min. lat. 13.2 mm., alt. 7.5 mm.; aperture: maj. lat. 6.6 mm., alt. 7.2 mm.; umbilicus about 2 mm.

SONORELLA BAILEYI ORCUTTI new subspecies

(PLATE XXXIII, FIGURE 5)

A lot of specimens collected by Mr. Orcutt in the Colorado desert agree in nuclear character and in many other respects with *S. baileyi*, but differ in the deflection of the aperture which is greater, and in its shape which is more oval; the umbilicus is also larger. This variety may be called *Sonorella baileyi orcutti*. The type (No. 175,082, U. S. Nat. Museum) measures: maj. lat. 16 mm., min. lat. 13.7 mm., alt. 9.1 mm.; aperture: maj. lat. 7 mm.; alt. 6.8 mm.; umbilicus about 3.5 mm.

GROUP OF *S. magdalensis*

SONORELLA MAGDALENENSIS Stearns

(PLATE XXXIII, FIGURE 2)

Helix (Arionta) magdalenensis STEARNS. Proc. U. S. Nat. Mus., vol. XIII, pp. 207–208, pl. XV, figs. 7, 11, 13 [not 12, which is *S. coloradoensis* Stearns].

Helix magdalenensis PILSBRY, Man. Conch., vol. VIII, pp. 226–227, pl. lvi, figs. 4, 5, 6, 1893.

Epiphragmophora magdalenensis PILSBRY, Man. Conch., vol. IX, p. 199, 1894.

Epiphragmophora magdalenensis (in part) DALL, Proc. U. S. Nat. Mus., vol. XIX, p. 339, 1896.

Epiphragmophora magdalenensis (in part) PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Helix magdalenensis E. v. MARTENS, Biol. Cent. Am., pp. 144, 624, 1901.

Sonorella magdalenensis PILSBRY, Proc. Acad. Nat. Sci. Phil'a, p. 560, 1901.

This species is the sole representative of this group in our collection, and the type and type lot are the only true *S. magdalenensis*, all the other forms referred here belonging to different species. The type was collected in the mountains above the town of Magdalena, Sonora, Mexico, at an altitude of 1,000 ft. It measures: maj. lat. 12.3 mm., min. lat. 10.2 mm., alt. 6.5 mm.; aperture: maj. lat. 6 mm., alt. 5.5 mm.; umbilicus about 1.8 mm.

GROUP OF *S. fisheri*

SONORELLA FISHERI new species

(PLATE XXXIII, FIGURE 3)

Epiphragmophora magdalenensis (in part) DALL, Proc. U. S. Nat. Mus., vol. XIX, p. 339, 1896.

Epiphragmophora magdalenensis (in part) PILSBRY AND JOHNSON, Nautilus, p. 59, 1897.

Shell small, depressed, horn-colored, with a moderately broad chestnut band edged by a scarcely perceptible lighter zone encircling the whorls a little above the periphery. This band is covered by the succeeding turns in all but the last one and one-half volutions. The nepionic stage embraces about one-half of a whorl, is rather depressed, and quite strongly transversely wrinkled. The neanic stage consists of one and one-third turns, which have been described in the definition of the section. Ephebic whorls two and one-half, depressed, moderately well rounded, a little more convex below than above, marked by many strong, wavy, and wrinkled incremental lines and numerous almost round, raised papillæ which form oblique, curved, interrupted lines extending from the summit of the whorls forward and downward, and are equally strong between the sutures on the periphery and the base; in the umbilicus, however, they are much heavier, assuming a warty appearance. The last whorl is gradually but considerably deflected at the aperture. Aperture moderately large, rounded oval, very oblique, scarcely at all expanded. Columella slightly expanded at base and but slightly reflected over the umbilicus. The type (No. 123,579, U. S. Nat. Museum) and type lot and another lot (No. 123,578) were collected by Dr. A. K. Fisher and E. W. Nelson on the Death Valley expedition at Johnson cañon, Panamint valley, California, at an altitude of 6,000 ft. The type measures: maj. lat. 15.5 mm., min. lat. 13 mm., alt. 8 mm.; aperture: maj. lat. 7 mm., alt. 6.5 mm.; umbilicus about 1.8 mm.

SONORELLA LOHRII (Gabb)

(PLATE XXXII, FIGURE 1)

Helix lohrii GABB, Am. Journ. Conch., vol. III, p. 336, pl. XVI, fig. 2, 1867.

Helix lohrii COOPER, Am. Journ. Conch., vol. IV, p. 235, 1868.

Helix rowelli (in part) G. W. BINNEY AND T. BLAND, Land and Freshwater Shells Am., pt. I, pp. 185–186, 1869.

Helix lohrii (in part) PILSBRY, Man. Conch., vol. IV, p. 172, pl. 15 [fig. 13], 1888.

Helix lohrii PILSBRY, Man. Conch., vol. VIII, pp. 226–227, 1893.

Epiphragmophora lohrii PILSBRY, Man. Conch., vol. IX, p. 199, 1894.

Helix lohrii FISCHER AND CROSSE, Miss. Scient. Mex., vol. II, p. 152, 1900.

Sonorella lohri PILSBRY, Proc. Acad. Nat. Sci. Phil'a, 1900, p. 560, 1901.
Sonorella lohri PILSBRY, Nautilus, vol. XVI, p. 32, 1902.

Our specimens of this species are either bleached or badly worn; a single individual only is fairly perfect, the neanic whorls of which indicate that it probably belongs to this group. The very strongly expanded and reflected aperture forms a quite strong peristome which readily distinguishes this species from all the other Sonorellas. All our specimens are from Lower California. One measures: maj. lat. 21.4 mm., min. lat. 16.4 mm., alt. 8.8 mm.; aperture: maj. lat. 11.6 mm., alt. 10.6 min.; umbilicus about 4.4 mm.

SONORELLA LOHRII LIODERMA Pilsbry

Sonorella lohrii liodenna Pilsbry, Nautilus, vol. XVIII, p. 59, 1904.

The shell is similar to *lohrii,* but the last whorl is a little more convex and evenly rounded, and the last two whorls are glossy, with no granulation, being marked with faint growth-striæ only. The spire is sometimes a little more elevated than the type of *S. lohrii.*

Near Moleje, Lower California, cotypes No. 58,107 and No. 88,-367, A. N. S. P., the latter from Lower California without special locality.

The type specimen of *S. lohrii* Gabb is finely granulated throughout.

[The above description came to hand while this paper was going through press.]

SEDIS INCERTÆ

SONORELLA ARIZONENSIS (Dall)

(PLATE XXXIII, FIGURE 6)

Epiphragmophora arizonensis DALL, Proc. U. S. Nat. Mus., vol. XVIII, pp. 1-2, 1895.
Epiphragmophora arizonensis DALL, Proc. U. S. Nat. Mus., vol. XIX, pp. 337-339, pl. xxxi, figs. 11, 12, 1896.
Epiphragmophora arizonensis PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.
Sonorella arizonensis PILSBRY, Proc. Acad. Nat. Sci. Phil'a, 1900, p. 560, 1901.

The type of *Sonorella arizonensis* Dall was collected by Major E. A. Mearns, U. S. A., at Santa Cruz river, Tucson, Arizona. It measures: maj. lat. 17.2 mm., min. lat. 14.1 mm., alt. 11.3 mm.; aperture: maj. lat. 9.5 mm., alt. 8.6 mm.; umbilicus about 1.7 mm. The nuclear whorls of the type and only specimen (No. 130,002, U. S. Nat. Museum) are too much worn to enable a determination of the proper systematic position of this species in the genus.

SONORELLA ROWELLI (Newcomb)

Helix rowelli NEWCOMB, Am. Journ. Conch., vol. I, p. 346, 1865. (Nomen nudum.)

Helix rowelli NEWCOMB, Proc. Acad. Nat. Sci. Cala., vol. III, p. 181, 1866.

Aglaja rowellii TRYON, Am. Journ. Conch., vol. II, p. 316, 1866.

Helix rowelli COOPER, Proc. Acad. Nat. Sci. Cala., vol. III, p. 337, 1867.

Helix rowelli W. G. BINNEY AND T. BLAND, Land and Fresh-water Shells Am., pt. I, p. 185, fig. 326, 1869.

Helix rowelli FISCHER AND CROSSE, Miss. Scient. Mex., vol. I, pp. 252–253, 1870.

Helix rowelli PILSBRY, Man. Conch., vol. IV, p. 72, pl. 15 [fig. 12], 1888.

Helix rowelli STEARNS, Proc. U. S. Nat. Mus., vol. XVIII, p. 207, 1890.

Helix rowelli E. VON MARTENS, Biol. Cent. Am., p. 144, 1901.

Helix rowelli PILSBRY, Man. Conch., vol. VIII, p. 226, 1893.

Epiphragmophora rowelli PILSBRY, Man. Conch., vol. IX, p. 199, 1894.

Helix rowelli DALL, Proc. U. S. Nat. Mus., vol. XIX, pp. 338–339, 1896.

Epiphragmophora rowelli PILSBRY AND JOHNSON, Nautilus, vol. XI, p. 59, 1897.

Helix rowelli FISCHER AND CROSSE, Miss. Scient. Mex., vol. II, p. 679, 1900.

Sonorella rowelli PILSBRY, Proc. Acad. Nat. Sci. Phil'a, 1900, p. 560 (1901).

Sonorella rowelli PILSBRY, Nautilus, vol. XVI, p. 23, 1902.

Sonorella rowelli is said to have been collected by Frick in Arizona. Dr. Dall (loc. cit.) gives the measurements of one of the specimens from the type lot as: maj. lat. 19 mm., min. lat. 14.5 mm., height 9 mm.

EXPLANATION OF PLATES

(The illustrations accompanying this paper are after photographs made from the specimens by Mr. T. W. Smillie, Chief Photographer, U. S. National Museum.)

PLATE XXVIII

Nuclear whorls of *Sonorella wolcottiana* Bartsch, enlarged about 21 diameters.

PLATE XXIX

Nuclear whorls of *Sonorella hachitana* Dall, enlarged about 21 diameters.

PLATE XXX

Nuclear whorls of *Sonorella fisheri* Bartsch, enlarged about 21 diameters.

PLATE XXXI

(Three views are given of each species—dorsal, profile, and ventral. The figures are natural size and the major latitude of the specimen figured follows the reference in each case.)

1. *Sonorella dalli* Bartsch; Type; 26.5 mm.; p. 193.
2. *Sonorella hachitana* Dall; Type; 23.7 mm.; p. 190.
3. *Sonorella nelsoni* Partsch; Type; 25.5 mm.; p. 191.

4. *Sonorella wolcottiana* Bartsch; Type; 23.5 mm.; p. 188.
5. *Sonorella ashmuni* Bartsch; Type; 28.2 mm.; p. 190.

PLATE XXXII

1. *Sonorella lohrii* Gabb; 21.4 mm.; p. 197.
2. *Sonorella mearnsi* Bartsch; Type; 16 mm.; p. 194.
3. *Sonorella coloradoensis* Stearns; Type; 16.4 mm.; p. 189.
4. *Sonorella granulatissima* Pilsbry; 19.7 mm.; p. 193.
5. *Sonorella merrilli* Bartsch; Type; 22 mm.; p. 192.
6. *Sonorella goldmani* Bartsch; Type; 22.5 mm.; p. 192.

PLATE XXXIII

1. *Sonorella indioensis* (Yates); 17.8 mm.; p. 189.
2. *Sonorella magdalenensis* Stearns; Type; 12.3 mm.; p. 196.
3. *Sonorella fisheri* Bartsch; Type; 15.5 mm.; p. 197.
4. *Sonorella baileyi* Bartsch; Type; 15.1 mm.; p. 195.
5. *Sonorella baileyi orcutti* Bartsch; Type; 16 mm.; p. 196.
6. *Sonorella arizonensis* Dall; Type; 17.2 mm.; p. 198

SONORELLA WOLCOTTIANA BARTSCH; NUCLEAR WHORLS, MUCH ENLARGED

SONORELLA HACHITANA DALL; NUCLEAR WHORLS, MUCH ENLARGED

SONORELLA FISHERI BARTSCH; NUCLEAR WHORLS, MUCH ENLARGED

SPECIES OF SONORELLA

SPECIES OF SONORELLA

SPECIES OF SONORELLA

ON SILURIC AND DEVONIC CYSTIDEA AND CAMAROCRINUS

By CHARLES SCHUCHERT

Introduction

The Ontaric or Siluric system of eastern United States is terminated by the Manlius formation, above which is the Helderbergian group with its prolific fauna so unlike those of older American deposits. Heretofore the fauna of the Manlius has been regarded as a very small one and is essentially described in three places, by Hall,[1] Whitfield,[2] and Grabau.[3] It is now quite evident, however, that this formation has a much more extensive fauna than has been surmised.[4] This is true not only for New York west of the Helderberg mountains, but especially for Pennsylvania and Maryland. Along the eastern escarpments of the Helderberg mountains these deposits include only the upper half of the beds known farther west and south, and the strata consist of thin-bedded limestones with the fossils either poorly preserved or not separable from the matrix. West of the Helderberg mountains, but more particularly in Pennsylvania and Maryland, considerable beds of shale occur in the lower half of the Manlius, and locally quantities of fossils, especially of bryozoa, are here found. One of the best places in Pennsylvania exposing this formation is at Clark's Mills, near New Bloomfield; at this locality cystids are rare, but the bryozoa occur abundantly. Near the southern border of Pennsylvania *Stromatopora* is common. About Cumberland, Maryland, bryozoa and a few species of corals and brachiopods predominate, and 30 miles to the southwest, near Keyser, West Virginia, cystids, bryozoa, and some forms of brachiopods are the prevailing fossils.

Owing to extensive alterations and improvements in the road-bed of the Baltimore and Ohio railroad, much ballast has been required, and one of the quarries established for the purpose of obtaining road metal was located near the town of Keyser, West Virginia. It

---

[1] *Nat. Hist. N. Y., Pal.*, III, 1859 [1861].

[2] *Geol. Surv. Ohio, Geol.*, VII, 1893.

[3] *Bull. Geol. Soc. Amer.*, 11, 1900, pp. 347-376.

[4] Since this was written, Weller has added a number of new species. See *Geol. Surv. New Jersey, Pal.*, III, 1903.

is reported that this railroad has spent upward of $2,000,000 in this quarry alone during the last three years. The great amount of work thus represented has made it possible to obtain a new and unique Manlius fauna. In the quarry in question the strata stand nearly vertical; as the shaly cystid zone is deeply decomposed, most of it had to be carted away as of no value to the railroad. This material, however, proved of great interest to the paleontologist. Unfortunately all the refuse from this great quarry is thrown together; otherwise an abundance of fine cystids might be obtained from these dumps for years to come.

Soon after the quarry was opened, Messrs. Robert H. Gordon and Frank Hartley, of Cumberland, Maryland, in collecting here, began to find excellent brachiopods and some cystids. After a few *Sphærocystites* had been obtained by Mr. Hartley, he interested the foreman, Mr. Joseph Gambino, and the gang of Italian laborers by showing them the specimens and offering to purchase any material found. He little dreamed that a few weeks later he would be offered a quart of these cystids, yet on each succeeding visit during the first year he obtained a like quantity. This activity on the part of these Cumberland collectors and the quarrymen yielded more than five thousand cystids, all of which have passed through the writer's hands. Such wholesale collecting undoubtedly explains why so many species have been found. With the cystids occur about ten species of crinoids, but these are always rare and none is known to be represented by more than five specimens. Other associated fossils are bryozoa and a few species of brachiopods.

Nearly all the specimens from the cystid layers in the Keyser quarries are uninteresting when picked up, because of the firm adherence of the shale, structural details thus being obscured. Weathering does not improve these fossils, as they are not completely siliceous, and all must be cleaned with potash to reveal their beautiful detail. For the benefit of those unacquainted with this method of preparing specimens for the cabinet or for study, the following extract, taken from *Directions for Collecting and Preparing Fossils*[1] is here added:

"To remove hard clay from the calyxes of corals or the interior of shells and other objects, caustic potash is often very serviceable. Fossils cleaned in this way, however, must be solid and without cracks, for the potash will penetrate into the minutest fracture and force the parts asunder. 'Caustic potash' comes in [purified] round, slender sticks sealed in one-half and one-pound bottles. Keep the potash sealed in the bottles with paraffin and cork stoppers. Handle

[1] Schuchert, *Bull. 39, U. S. Nat. Mus.*, Pt. K, 1895.

the pieces with iron forceps, not with the fingers. In cleaning fossils have the parts to be acted on uppermost, and on these lay small pieces of solid caustic potash. After the potash has acted for a day or so wash the dirt away which rises in puffed masses, and continue the application of fresh potash until the parts are cleaned. To get rid of all potash, which if not removed will for years after come to the surface in a white film, soak the fossils in many changes of water to which has been added a few drops of muriatic acid, and brush repeatedly. Sometimes the white film is a product of decomposition and cannot be wholly removed. It can then be darkened with india ink or some suitable color."

The cystid fauna continues through about 37 feet of shale and is then suddenly terminated by a heavy-bedded impure limestone in which *Camarocrinus* abounds. In no other place have these forms been found in abundance, though occasionally a specimen is picked up at Devil's Backbone, Cash valley, and in the city of Cumberland. For the sake of completeness the detail of the Manlius formation, as exposed in the quarries near Keyser, is here presented:

SECTION OF MANLIUS FORMATION AT B. & O. R. R. BALLAST QUARRIES NEAR KEYSER, WEST VIRGINIA.[1]

Coeymans limestone. Base of Devonic:

	Ft.	In.
6. Heavy-bedded solid blue limestone. No fossils seen....	34	6
5. A solid blue limestone, filled with a small form of *Gypidula* near *G. galeata*.........................	2	
4. Heavy-bedded impure limestone, with an abundance of *Camarocrinus* and more rarely *Tentaculites gyracanthus, Calymmene camerata*, and *Trimerocystis peculiaris*	6	
3. Cystid beds. Thin-bedded shaly limestone and shale, deeply weathered. Throughout this zone *Sphærocystites multifasciatus, S. globularis, Pseudocrinites gordoni*, and *Jaekelocystis hartleyi* abound. *Pseudocrinites stellatus, P. clarki, P. perdewi, Jaekelocystis papillatus, J. avellana, Lepocrinites manlius*, and *Tetracystis chrysalis* occur more rarely.........	37	
2. A solid blue limestone................................	2	4
1. Thin-bedded shaly limestone like 4. Toward the base occur *Nucleospira, Rhynchonella* like *campbellana*, and *Spirifer octocostatus*..........................	28	6

Salina formation, 1125 feet:

[1] See also Schuchert, *Proc. U. S. Nat. Mus.*, XXVI, 1903, pp. 413-424.

Phylum *ECHINODERMA* Bather

Grade PELMATOZOA Leuckart

Class *CARPOIDEA* Jaekel

Jaekel[1] defines this class as follows:

"Carpoidea are aberrant, irregular Pelmatozoa, whose ambulacral organs had but slight connection with the thecal skeleton and on which it generally left but slight traces of its existence. Their thecæ form a closed capsule whose wall has a mouth and anus. The thecal skeleton is always apentamer, often distorted, mostly oriented dorso-ventrally, and more or less symmetrical on the right and left. The ambulacra are developed in two radii. The known bearers of the ambulacral grooves are arranged in a single line. The base has four or three pieces, the stem consists mostly of two series of symmetric parts, and sometimes has metamerally ordered genital appendages. Their geological distribution is in the Cambrian and Silurian."

The range should extend from the Cambrian into the Lower Devonic, as *Anomalocystites* (?) *disparilis* Hall is found in the Upper Oriskany formation.

Family ANOMALOCYSTIDÆ Meek

This family is defined by Jaekel in the work just cited (p. 668), as follows: "Theca oval, nearly symmetrical, and both broad sides having similar skeletal plates. Ventralia only about twice as numerous as the dorsalia. Three to four marginalia on each side with angulated side margins. Base deeply impressed; the stem occupies the entire breadth of the basalia. Thecal plates ornamented with horizontal wavy lines." In *Anomalocystites* there are 2 stout and short arms composed of imbricating plates in 2 columns, having great ambulacral furrows covered by minute roofing plates. In *Placocystites* and seemingly, also, in *Anomalocystites* (?) *disparilis* the arms are replaced by long and slender, apparently non-segmented spines.

Anomalocystites Hall

Anomalocystites HALL, Amer. Jour. Sci. (2), XXV, 1858, p. 279.—HALL, Nat. Hist. N. Y., Pal., III, 1859 [1861], p. 132.—MEEK (partim), Geol. Surv. Ohio, Pal., I, 1873, p. 43.—BARRANDE (partim), Syst. Sil. du Centre de la Bohême, VII, pt. I, 1887, p. 89.

Ateleocystites WOODWARD (partim), Geol. Mag., dec. II, VII, 1880, pp. 193, 194.

Anomocystis HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 40.

Anomalocystis BATHER, Treatise on Zoology, pt. III, Echinoderma, London, 1900, p. 51.

[1] *Zeits. Deutsch. geol. Gesellsch.*, 1900, p. 662.

Original description.—"Body semielliptical or semiovoid; sides unequal; the vertical outline oval or ovoid, plano-convex or concavo-convex; the transverse outline semielliptical, the base of which is straight or more or less concave: the two sides composed of an unequal number of plates. Basal plates three on the convex [or ventral] side, two [=medial basals] on the concave [or dorsal] side; second series, two large plates at the angles [=lateral basals], and four (or five?) [anal] on the convex side; third series, four [anals] on the convex side, one at each angle, and a large plate on the concave side; a fourth, fifth, and sixth series of anal plates on the convex side, and a fourth series on the concave side. Base oblique, with the convex side longer, and a deep concavity for the insertion of the column. Pectinated rhombs apparently none. Arms unknown. Column deeply inserted into the body, composed of large joints above, becoming smaller below." (See fig. 21.)

No species is here mentioned, but in Hall's next account of this genus the first species and the one generally accepted as the genotype is *A. cornutus* Hall.

To the above generic description should be added the following: On the convex or ventral side of both *A. cornutus* and *A.* (?) *disparilis,* between the two lowest plates of the median column, there is always seen a rather small opening. In examples of *A. cornutus* the calcareous plates are not metamorphosed, but they are usually somewhat displaced and one can not be certain that this hole is not accidental. In *A.* (?) *disparilis,* specimens of which are always preserved as delicate pseudomorphs, all have a large unmistakable opening in the same position. In a crushed example of *Placocystites forbesianus* in the National Museum, there also appears to be an aperture on the ventral side, but here it is one plate higher toward the mouth. In the writer's opinion, this opening must be the anus, but as the evidence is not conclusive, the fact can not be stated with certainty.

Arms 2, free, small, and composed of 2 ranges of alternate, imbricating, thin pieces. Ambulacral furrows very wide and deep; ambulacralia minute, about 5 to each ambulacral piece. Column short, with a great central canal, consisting of numerous, imbricating, very narrow segments, each composed of 2 pieces. The suture lines of the columnals are on the dorsal and ventral sides.

Anomalocystites has been regarded as the same as *Ateleocystites* Billings and *Placocystites* de Koninck. *Ateleocystites* is from the middle of the American Lower Siluric and is not well known, but appears to be distinct. *Placocystites,* so completely worked out by Woodward in the work above cited, has on the anterior side the same number and arrangement of thecal plates as in *Anomalocystites.* The arrangement of the plates on the anal side, however, is quite different, there being 6 more or less complete columns in *Anomalocystites,* whereas *Placocystites* has only 4 series.

So far as known, *Anomalocystites* is restricted to the American Lower Devonic.

ANOMALOCYSTITES CORNUTUS Hall

(PLATE XL, FIGURES 4, 5)

Anomalocystites cornutus HALL, Nat. Hist. N. Y., Pal., III, 1859 [1861], p. 133, pl. 7A, figs. 5-7.—WOODWARD, Geol. Mag., dec. II, VII, 1880, p. 193, pl. 6, figs. 4, 5.

Anomalocystis cornuta HAECKEL, Die Amphorideen, etc., 1896, p. 41, pl. 2, figs. 8, 9.

Length of theca 12 mm.; width 9 mm.; depth about 3 mm.

Theca subovoid, with the anal side depressed convex and the anterior side slightly concave. Lower half of theca with the plates sculptured by transverse wavy lines and the upper half with widely separated depressed pustules. Plates arranged as in figure 21.

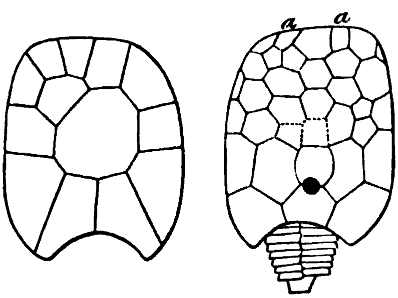


FIG. 21.—Analysis of both sides of *Anomalocystites cornutus* Hall. (*a, a,* Plates to which the two free arms are attached. The black spot indicates the probable position of the anus.)

Arms small, tapering rapidly, sharply angulated medially on the adambulacral side, about 6 to 7 mm. long, and composed of about 20 pieces in each column. Ambulacra very wide and deep; there appear to have been near the base of the arms about 3 or 4 ambulacralia to each arm-plate.

Column short, about 18 mm. long, and composed of about 64 narrow and 7 wide segments, each consisting of 2 pieces. The segments on each side, alternate with those of the opposite, are thin walled, imbricating, and with a great central cavity.

Formation and locality.—Not rare in the Coeymans limestone of the Lower Devonic of Litchfield township, Herkimer county, New York. The writer found one small slab having at least three fair specimens and possibly a dozen or more with the plates separated. Another slab shows a theca with the entire column.

Cat. numbers 35,078, 35,079, U. S. N. M.

ANOMALOCYSTITES (?) DISPARILIS Hall

Anomalocystites disparilis HALL, Nat. Hist. N. Y., Pal., III, 1859 [1861], p. 145, pl. 88, figs. 1-4.—WOODWARD, Geol. Mag., dec. II, VII, 1880, p. 193, pl. 6, figs. 2, 3.

Of this species the writer has seen eight specimens, six of which were collected by Mr. Hartley and two by Mr. Perdew. These permit the exact determination of the thecal plates, and the position of the two spines, all of which are shown in the diagrams in figure 22. Detail of spines and column and the surface ornamentation undetermined on account of the pseudomorphous condition of the fossils.

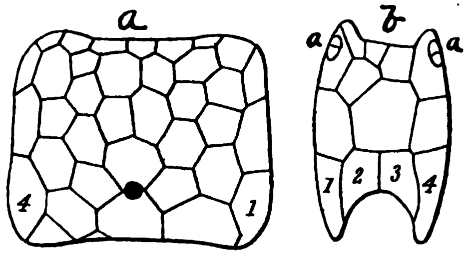


FIG. 22.—Analysis of both sides of *Anomalocystites (?) disparilis* Hall; natural size. (*a*, The ventral side with the plates projected on a plane; *b*, the dorsal side with the free arm facets shown at *a*, *a*. The black spot indicates the probable position of the anus.)

Length of largest theca 28 mm.; width 18 mm.; depth in basal region 13 mm., and in anterior region 7 mm.

Anal side convex, with more or less abrupt sides. Anterior side but slightly excavated, regularly or irregularly, with the lateral margins sharply elevated.

This species is easily separated by its larger size, more elongate and narrower theca, and the greater convexity of the anal side.

It is not yet established that *A.* (?) *disparilis* actually belongs in the genus *Anomalocystites*. In the genotype there are 2 arms with imbricating plates, while in the Oriskany species these are apparently replaced by spines of 1 piece, as in *Placocystites*. Further, in *A.* (?) *disparilis* the theca between the spines has a large, elongate-quadrate opening, which, in the best-preserved specimen, is about half closed by an inclined plate extending from the anal side over the aperture. In this specimen the longer edges of this opening are striated, suggesting a pectinirhomb. However, as all the specimens are poorly preserved siliceous pseudomorphs, one can not make out the exact nature of this opening. The differences pointed out between *A. cornutus* and *A.* (?) *disparilis* seem to indicate that the two species may not belong to the same genus.

Formation and locality.—Found in the upper half of the Oriskany sandstone associated with the *Spirifer arenosus* fauna. It is probably not a rare species, yet owing to the pseudomorphous, thin-shelled, hollow condition of the fossils, but few specimens hold together for the collector. All the specimens examined were found in the vicinity of Cumberland, Maryland.

Cat. number 33,661, U. S. N. M.

Class *CYSTOIDEA* Jaekel[1]

"*Definition.*—Cystoidea are Pelmatozoa whose cup or 'theca' is closed to the mouth, penetrated by pores (thecal pores), and whose ambulacral radial vessels have egress only through the mouth. The skeleton of the theca consists of non-movable polygonal plates, very rarely without a stem and by which it is anchored or free. The ambulacral radial-vessels are either restricted to the region about the mouth or they bifurcate and spread over the theca, but are always elevated distally in skeletal arm-appendages ('fingers'). The fingers [brachioles is the term used in this paper] are biserial, undivided, and have groove-plates [= ambulacralia of this paper], but are without pinnules. The mid-gut is solar, the end-gut often turned to one side, the anus is in the side of the theca, not always in interradius I:V, but is always situated outside of the bases of the fingers and generally is closed by a plated pyramid. As sexual organs the axial-sinus of the body-cavity originally functioned, opening outwardly in a pore ('parietal pore'), suborally in the interradius I:V. The position of the primary stone-canal remains fairly constant and opens outwardly near the mouth and above the parietal pore [in the following pages the writer has used the term hydropore] in the madreporite, but sometimes through regression is united with the parietal canal. The latter, the primary stone-canal, and their pores are situated in the vertical-mesenterium ('parietal septum')."

Order DICHOPORITA Jaekel

"*Definition.*—Dichoporita are Cystoidea whose thecal-pores are in pairs, each pair divided between two plates, situated vertically across the suture lines, slit or tubular-form, arranged parallel and combined into pore-rhombs [= pectinirhombs of this paper], their ambulacral radial-grooves in special skeletal elements supported by the theca." (Jaekel, p. 178.)

Suborder REGULARIA Jaekel

Dichoporita with the "theca having a base of four plates and four circles each normally made of five pieces. Pores in open adjoining

[1] *Stammesges. d. Pel.*, Berlin, 1, 1899, p. 63.

or discrete-pectinirhombs having interior calcareous folds. At least one pectinirhomb is always situated on the basal opposite to the anus [plate 1]. Anus laterally above the widest basal. Column and roots well developed; the uppermost segments alternating with collared pieces." (Jaekel, p. 194.)

EXPLANATION OF SOME OF THE TERMS USED IN THE PRESENT WORK

Plate formula.—The system of numbering the thecal plates in the following descriptions and diagrams is that of Bather (*Treatise on Zool.*, III, 1900). These numbers were probably first applied by Edward Forbes as early as 1848. Hall, in 1852, used a similar notation in describing *Callocystites*. The diagram of the latter genus given on page 244 has the full number of plates, and the student should familiarize himself with it.

Theca.—The cup containing the viscera and composed of a variable number of *thecal plates*. The *mouth* is at the end opposite to that attached to the *column* or stem. From the mouth radiate the *ambulacra*. Just beneath the mouth is the small porous plate known as the *madreporite*, which is connected with the stone canal. Usually in contact with the madreporite is a very minute pore, the *hydropore* or parietal pore, and in well-preserved specimens this is closed by a pyramid of plates. Still further beneath the mouth is the large aperture of the *anus* closed by the *anal pyramid*. Besides these parts the theca always has 3 *pectinirhombs* situated on 6 plates, or on plates 1 and 5, 12 and 18, and 14 and 15.

Ambulacra.—The recumbent or prostrate arms upon the theca. The lower biserial pieces are the *ambulacrals* and the roofing pieces over the radial grooves are the *ambulacralia*. On and between the ambulacrals are the 'fingers' or *brachioles*.

Pectinirhomb.—The parallel dichopores arranged across a suture between 2 plates, and combined into a rhomb. When the two halves are not separated medially by walls they are here referred to as *pectinirhombs*, but when the two halves are distinctly separated and each part is surrounded by a wall, they are termed *discrete-pectinirhombs*.

Family CALLOCYSTIDÆ Bernard

This family is defined by Jaekel as follows:

Regularia with the " theca closed to the mouth, plates in the circles in complete numbers. Ambulacra with paired ambulacralia and parambulacralia, projected radially over the theca and provided with numerous brachioles (fingers). Anus of medium size, generally surrounded by a ring of marginal pieces. Pectinirhombs with the grooved recesses separated. Thecal plates generally sculptured with pits" (p. 266).

The family is subdivided by Jaekel into the following subfamilies:

Glyptocystinæ, the oldest and most primitive forms, with a single genus, *Glyptocystites* Billings.

Apiocystinæ, in which the ambulacra remain undivided, with widely separated brachioles. It includes *Meekocystis* Jaekel (only species *Lepocrinites moorei* Meek), *Apiocystites* Forbes, *Lepocrinites* Conrad, *Jaekelocystis* Schuchert, *Tetracystis* Schuchert, and *Hallicystis* Jaekel. The last genus is referred by Jaekel to Callocystinæ; the ambulacra, however, have not been seen, and in all the other characters *Hallicystis* agrees with *Apiocystites.*

Staurocystinæ, in which the ambulacra remain undivided, with the brachials closely crowded. It includes *Pseudocrinites* Pearce, *Trimerocystis* Schuchert, and *Staurocystis* Haeckel.

Callocystinæ has branching ambulacra, widely separated brachioles, and partial telescoping of the second and third rings of plates. It includes *Callocystites* Hall, *Cœlocystis* Schuchert, and *Sphærocystites* Hall.

Subfamily APIOCYSTINÆ Jaekel

Callocystidæ with the 4 or 5 ambulacra, simple, and relatively with widely separated brachioles.

Apiocystites Forbes

Apiocystites FORBES, Mem. Geol. Surv. Great Britain, II, pt. II, 1848, pp. 501, 503.—HALL, Nat. Hist. N. Y., Pal., II, 1852, p. 242.—JAEKEL (partim), Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 279.

Apiocystis HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 132.

Lepadocrinus BATHER (partim), Treatise on Zoology, pt. III, Echinoderma, London, 1900, p. 61.

Definition.—Apiocystinæ with the theca regularly oval, elongate, or slightly compressed (in the last case not strongly 4-sided), and composed of 19 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6, 7, 8, 9.

Third row has plates 10, 11, 12, 13, 14.

Fourth row has plates 16, 17, 18, 19, 15.

Fifth row has deltoid 23.

Deltoid 23 is very small, placed above plate 18, with the madreporite and hydropore present. Anal area small, placed between plates 7, 8, and 13, consisting of an outer complete circle of minute pieces and the pyramid of 5 pieces. One basal and 2 discrete-pectinirhombs, with small recesses and few dichopores.

Ambulacra 4, simple, narrow, and not prominent. These are R I, R II, R IV, R V, equally developed and generally continuing nearly or quite to the column. Brachioles few in number and more or less widely separated.

Genotype, *A. pentrematoides* Forbes (1 specimen in U. S. N. M., cat. number 35,137).

Lepocrinites gebhardii is usually referred to this genus, and although the species is closely related, it does not seem advisable to make *Lepocrinites* synonymous with *Apiocystites*. The latter undoubtedly represents an earlier stage in the development of *Lepocrinites*, but it is one that should be distinguished; it differs from the later type in having small discrete-pectinirhombs and narrower ambulacra, with the ambulacrals more elongate and narrower, causing the brachioles to become fewer in number (about 20 to 36 to an ambulacrum) and more widely separated. Moreover, the column in *Lepocrinites* is very peculiar in having 2 distinct parts—an upper consisting of about 15 segments, and a lower in which the segments are fused into a single long, swollen, leech-shaped piece. The latter is characteristic of the genus and is found abundantly in the Coeymans limestone at the base of the Devonic, while other parts of this cystid are very rarely obtained by collectors. For the differences between *Apiocystites, Tetracystis,* and *Jaekelocystis,* see the discussion under the last two genera.

The species referable to *Apiocystites* are the following: *A. pentrematoides* Forbes of the Wenlock limestone, Dudley, England; *Pseudocrinites oblongus* Forbes (partim) of the Wenlock limestone, Dudley, England; and *A. elegans* Hall of the Rochester shale at Lockport, New York, and Grimsby, Ontario.

Apiocystites canadensis Billings. The holotype of this species, which is preserved in the collections of the Geological Survey of Canada, proves to be a small or young specimen of *Callocystites*. The same form was later described by Ringueberg as *C. tripectinatus*. Further details will be found under *C. canadensis*, page 245.

Apiocystites imago Hall has been taken by Jaekel as the genotype of *Hallicystis*. It is described on page 216 in this memoir.

Apiocystites (?) *tecumseth* Billings. Through the courtesy of Professor Whiteaves the writer has seen the original " fragments of the column " described by Billings. The " detached plates " appear to be no longer in existence.

The columns are top-shaped bodies from 5 to 8 mm. long, with a large, round, central canal. The segmented central portion of the column is about 3 mm. in thickness, outside of which is a secondary non-segmented deposit, as in *Lepocrinites*, giving the stem a total diameter varying between 5 and 7 mm. The secondary deposit is ornamented with small, polygonal, shallow depressions arranged in circles.

Until the theca of *A.*(?) *tecumseth* is known, this can not be regarded as an established species.

Apiocystites(?) *huronensis* Billings. Through the courtesy of Professor Whiteaves the writer was allowed to study the holotype of this species. It certainly is not a form of *Apiocystites,* and probably represents a new genus, since the pectinirhomb of 12 and 18 rests directly on that of plates 1 and 5. In other words, plate 12 rests on plates 5 and 9—an anomalous position for the former plate, and one unknown in other American Siluric cystids. Billings's figure 28 is inverted in the text, with the column uppermost. This illustration shows all that is preserved in the holotype. The plates present are 4 and 1 of the first circle, 5 and 9 of the second, 12 of the third, and part of 18 of the fourth circle.

APIOCYSTITES ELEGANS Hall

(PLATE XXXIV, FIGURES 4, 5)

Apiocystites elegans HALL, Nat. Hist. N. Y., Pal., II, 1852, p. 243, pl. 51, figs. 1–17.

To Hall's description (based on Lockport specimens) may be added the following details seen in a very fine specimen in the collection of Dr. B. E. Walker, Toronto, Ontario. It was found by Mr. J. Pettit in the Rochester shales at Grimsby, south of Hamilton, Ontario.

Length of theca 17 mm.; diameter about 13 mm. The specimen is somewhat distorted, so that the actual diameter is not determinable.

Ambulacra extending almost to the column, the pair, one on each side of the anus, slightly converging, as does also the opposite pair. Brachioles widely separated, from 11 to 12 on each side of an ambulacrum. Ambulacralia extremely small, about 12 to each ambulacral.

Pectinirhombs equal in size, each with about 10 dichopores. Those on plates 5, 12, and 14 with strongly elevated rims, while those on plates 4, 15, and 18 are almost without elevated margins.

Anal pyramid not seen, but probably composed of 5 or 6 pieces. It is surrounded by a prominent ring of 8 pieces set between plates 7, 8, and 13.

Lepocrinites Conrad[1]

Lepocrinites CONRAD, Ann. Rep. N. Y. Geol. Surv., 1840, p. 207.—VANUXEM, Nat. Hist. N. Y., Geol., III, 1842, p. 117, text-fig. 4.—MATHER, ibidem, I, 1843, p. 346, text-fig. 4.

Lepocrinus or *Lepadocrinus* HALL, Nat. Hist. N. Y., Pal., III, 1859, p. 125, pl. 7, figs. 1–20.

Apiocystites JAEKEL (partim), Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 279, fig. 59.

Lepadocrinus BATHER (partim), Treatise on Zoology, pt. III, Echinoderma, London, 1900, p. 61.—HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 134.

Conrad's original description reads as follows:

"Crinoidea. *Lepocrinites Gebhardii.* By this name I introduce a single fossil found by Mr. Gebhard. The body is composed of plates of unequal sizes, a few of which have ambulacra, connecting this fossil with the echinodermata; lower half of the column apparently solid and traversed by a pentangular canal."

This definition, as stated by Jaekel, is applicable to many Pelmatozoa, but Mather's fairly good figure, published in 1843, gave the genus and species standing among American collectors. From the standpoint of proper definition, *Lepocrinites* dates from Hall's redescription of the genus in 1859, where he changes the orthography to *Lepocrinus* or *Lepadocrinus* because "the name *Lepocrinites* was given from the resemblance to the Lepas or Barnacle, *Antifa*, and is properly *Lepadocrinus*." Jaekel rejects Conrad's name, because the genus can not be recognized from his description; and Hall's, on the ground of priority, yet makes both synonymous with *Apiocystites* Forbes of 1848. Bather rightly goes back to the first clear usage of the name, giving the genus to Mather because of his fairly accurate figure, but accepts Hall's corrected orthography, *Lepadocrinus*. The writer prefers to adhere rigidly to the rules of nomenclature, hence makes use of the name as given by both Conrad and Mather—*Lepocrinites.*

Definition of Lepocrinites.—Apiocystinæ, with the theca oval or pyriform, the sides somewhat compressed, and composed of 20 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

---

[1] This name is usually written *Lepadocrinus*. The *Code of Nomenclature adopted by the American Ornithological Union*, 1892, p. 51, states: "The original orthography of a name is to be rigidly preserved, unless a typographical error is evident." As there is no evident typographical error in Conrad's proposal of the name, the writer preserves the original orthography.

Second row has plates 5, 6, 7, 8, 9.
Third row has plates 10, 11, 12, 13, 14.
Fourth row has plates 16, 17, 18, 19, 15.
Fifth row has deltoid 23.

Deltoid 23 is very small, situated on top of plate 18, or between it and 13. The hydropore and madreporite are present. Anal area small, placed between plates 7, 8, and 13, and consisting of an outer complete circle of a variable number of small pieces and the pyramid of 6 pieces. One basal and 2 upper pectinirhombs, having long, angulated, grooved, adjoining recesses, with numerous dichopores.

Ambulacra 4, not prominent, undivided, and usually not longer than one-half the length of the theca. Brachioles not abundant.

Column unlike those of all associated genera in being composed of 2 distinct parts. Beneath the theca there are about 15 segments followed by a thicker leech-shaped piece from 35 to 55 mm. in length, formed of segments anchylosed together and coated over on the outside by a nodose layer. The lower end of the fused piece seems to have articulated directly with the basal expansion.

Genotype, *L. gebhardii* Conrad.

Lepocrinites is undoubtedly closely related to *Apiocystites*, but should not be confounded with it, on account of differences pointed out in the remarks on the latter genus. The peculiarity of the column alone should distinguish *Lepocrinites* from all other associated genera. The fused piece of the column is often extremely abundant in certain crinoidal limestones of the Coeymans at the base of the Devonic in Litchfield and Schoharie counties, New York.

The earliest species is *L. manlius*, found near the top of the American Siluric; this is followed by *L. gebhardii* of the basal Devonic. *L.* (?) *angelini* Haeckel of the Upper Siluric of Gotland may also prove to belong here, and not to *Apiocystites*, on account of the large adjoining pectinirhombs, with numerous dichopores, the similar structure of the ambulacra, and the more numerous brachioles.

LEPOCRINITES MANLIUS n. sp.

(PLATE XXXVII, FIGURES 2, 3; PLATE XXXIX, FIGURES 15, 16)

Length of theca 2 cm.; greatest width 14 mm.; depth 12 mm. For general form, shape of individual plates and their ornamentation, see the figures and diagram, figure 23.

Each ambulacrum a little longer than half the length of the theca and bearing on each side about 12 brachioles (or 24 to an ambulacrum), of which none is preserved.

Basal pectinirhomb largest, with about 40 dichopores, while the 2 upper ones each have about 35.

The conspicuous valvular pyramid of the anus is composed of 6 triangular plates surrounded by a circle of about 18 very small pieces. All these parts are deeply set between plates 7, 8, and 13.

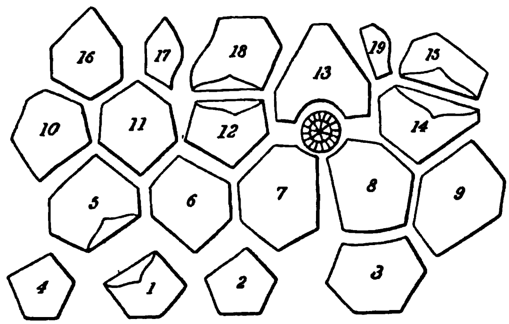


FIG. 23.—Analysis of *Lepocrinites manlius* n. sp.

Hydropore small, placed just below the conspicuous madreporite. Both are situated on plate 21, making the abutment on one side for 2 ambulacra.

Column unknown. In the cystid layer, however, occur the fused leech-shaped pieces of the column, so characteristic of *Lepocrinites*. They are smaller than in *L. gebhardii* and, as they occur in the same zone as the theca of *L. manlius,* it is probable that these pieces belong to the latter species.

Compared with *L. gebhardii* of the Coeymans, *L. manlius* is considerably smaller, in form more pyriform than subquadrate, has considerably longer ambulacra, and the plate ornamentation is far more decided.

Formation and locality.—The only specimen was found by Mr. Gordon at the Keyser quarries in the lower portion of the Manlius. The species takes its name from the Manlius formation, the horizon just beneath the Coeymans in which *L. gebhardii* occurs.

Cat. numbers 35,062, 35,073, 35,074, U. S. N. M.

LEPOCRINITES GEBHARDII Conrad

Lepocrinites gebhardii CONRAD, Fourth Ann. Rep. N. Y. Geol. Surv., 1840, p. 207.—VANUXEM, Nat. Hist. N. Y., Geol., III, 1842, p. 117, text-fig. 4.—MATHER, ibidem, I, 1843, p. 346, text-fig. 4.—HALL, ibidem, IV, 1843, tab. ill. 27, fig. 4.—OWEN, Amer. Jour. Sci. (2), 1846, p. 49, fig. 4 (fig. only).—LINCKLAEN, Fourteenth Rep. N. Y. State Cab. Nat. Hist., 1861, p. 58, pl. 9, fig. 11.

Lepadocrinus gebhardi HALL, Nat. Hist. N. Y., Pal., III, 1859 [1861], p. 127, pl. 7, figs. 1–20.—HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 135.

Apiocystites gebhardii JAEKEL, Stammesgeschichte der Pelmatozoen. I, Berlin, 1899, p. 282, fig. 59 on p. 280.

The writer has seen a number of specimens of this species belonging to Yale University Museum and to the U. S. National Museum, but their preservation is such that nothing can be added to the description and illustrations given by Hall except the structure of the anal area. This is composed of 2 circles of pieces—an outer of many small plates and the pyramid.

Formation and locality.—In the upper portion of the Coeymans limestone of the Lower Devonic, at many places in eastern New York. It has not been found, to the writer's knowledge, south of New York.

Cat. numbers 10,557, 26,923, 33,202, 35,075, 35,076, U. S. N. M.

Hallicystis Jaekel

Apiocystites HALL (not Forbes nor Hall, 1852), Twentieth Rep. N. Y. State Cab. Nat. Hist., rev. ed., 1868 [1870], p. 358.

Hallicystis JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, 1, 1899, p. 287.

Definition.—Apiocystinæ ? with the theca elongate balloon-shaped, base not invaginated, and with 5 rows of 4 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6, 7, 8, 9.

Third row has plates 10, 11, 12, 14.

Fourth row has plates 16, 17, 18, 13, 19, 15.

Fifth row has plate 20 and deltoids 21, 22, 23 double, 24.

Anus prominent, bounded by plates 7, 8, and 13. Pyramid enclosed by a complete circle of minute plates.

Pectinirhombs normally situated, discrete, with few dichopores.

Ambulacra 4. As all the specimens are internal casts, the details of the exterior cannot be ascertained.

Genotype, *Apiocystites imago* Hall.

This genus differs from *Apiocystites* in having 5 deltoids instead of 1, but otherwise seems to be closely related. Only two species are known.

HALLICYSTIS IMAGO (Hall)

Apiocystites imago HALL, Twentieth Rep. N. Y. State Cab. Nat. Hist., rev. ed., 1868 [1870], p. 358, pl. 12, fig. 12; pl. 12A, fig. 9.

Hallicystis imago JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, 1, 1899, p. 288.

Rare in the Niagaran dolomites about Chicago, Illinois.

The diagram of plates (figure 24) is based on specimen 35,060, U. S. N. M., and on material in Dr. B. E. Walker's collection.

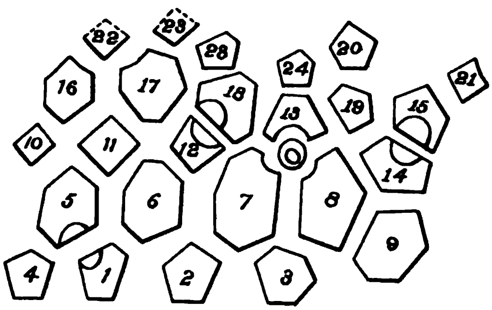


FIG. 24.—Analysis of *Hallicystis imago* Hall, based on no. 35,060, U. S. N. M., and on one of Walker's specimens.

HALLICYSTIS ELONGATA Jaekel

Hallicystis elongata JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 288.

The description, translated, is as follows:

"Theca greatly arched, 35 to 40 mm. high. Anus in the middle of the length, with a depression about its vicinity. Theca above the anus still convexly arched. Upper pectinirhomb on plates 14 and 15 of medium size, with 14 dichopores. Plates flat, rippled, folded toward the middle, and with concentric lines along the margins. Upper Silurian (Niagara limestone), Chicago."

Holotype in the University of Strassburg, Germany.

Tetracystis n. gen.

Definition.—Apiocystinæ with the theca elongate subquadrate, 4-sided in transverse section, and composed of 20 plates. These are arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6, 7, 8, 9.

Third row has plates 10, 11, 12, 14.

Fourth row has plates 16, 17, 18, 13, 19, 15.

Fifth row has deltoids 23 and 24. The former has a large hydropore and a small madreporite.

Anal area prominent, bounded by the thecal plates 7, 8, 13, and 14, and composed of an outer circle of many small pieces and the acutely pointed pyramid of 6 pieces. One basal and 2 large upper adjoining pectinirhombs, with numerous dichopores.

Ambulacra 4, simple, slender, and extending to the column. These are R I, R II, R IV, and R V. Brachioles very slender, widely separated, and therefore comparatively few in number.

Column unknown.

Genotype, *T. chrysalis* n. sp. The only other species is *T. fenestratus* (Troost).

As in *Staurocystis, Tetracystis* has the same arrangement of the thecal plates and of those in the anal area, but differs widely in the construction of the ambulacra. In the latter they are slender, inconspicuous, each with about 20 brachiole sockets, while in the former the ambulacra are wide, very conspicuous, heaped medially, and each bears about 40 brachioles. Moreover, deltoid 23 is a prominent plate in *Tetracystis,* while in *Staurocystis* it is probably very small, the relation of this genus being with *Pseudocrinites. Apiocystites* is also closely related to *Tetracystis,* but differs in having the 2 parts of each pectinirhomb discrete and the anal plates surrounded by thecal plates 7, 8, and 13; while in *Tetracystis* there is an additional plate, or 7, 8, 13, and 14. *Lepocrinites* differs in having but 3 thecal plates bounding the anal area instead of 4 as in the new genus. In *Jaekelocystis* plate 19 is lacking, the rhombs are quite different, and the anal area has not a second circle of small pieces as in *Tetracystis.*

TETRACYSTIS CHRYSALIS n. sp.

(PLATE XXXIV, FIGURES 9, 10; PLATE XL, FIGURES 1-3)

Length of theca of holotype 23 mm.; width 17 mm.; depth 13 mm. A single paratype has a length of 24 mm.; breadth 15 mm.; depth

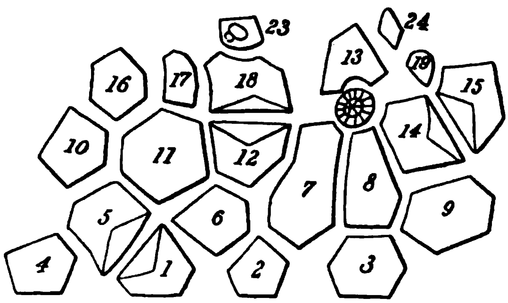


FIG. 25.—Analysis of *Tetracystis chrysalis* n. sp.

13 mm. For general form, shape of individual plates and their ornamentation, see the figures and diagram, figure 25.

Ambulacra narrow, depressed, not excavated into the thecal plates, and extending to the column. Ambulacrals very long and narrow, about 20 in a column. Ambulacralia extremely small, about 12 to 14 to each ambulacral. Brachioles very slender, about 11 on each side of an ambulacrum or about 88 to each theca; length unknown.

Pectinirhombs each with from 25 to 35 dichopores.

Hydropore on plate 23 comparatively large and easily seen; immediately behind it is a shallow pit with numerous pores, indicating the madreporite.

Anal area very prominent owing to the elevated anal margins of plates 7, 8, 13, and 14, and composed of an outer circle of 17 small pieces and a highly elevated pyramid of 7 pieces.

Column unknown.

Formation and locality.—The two specimens were found by Mr. Gordon in the cystid beds at the quarries near Keyser, West Virginia. The paratype is in Mr. Gordon's collection.

Cat. number 35,063, U. S. N. M.

TETRACYSTIS FENESTRATUS n. sp. (Troost)

(PLATE XXXIV, FIGURES 6-8)

Echinocrinites fenestratus TROOST, Amer. Jour. Sci. (2), VIII, 1849, p. 419 (nomen nudum).

Echino-encrinites fenestratus TROOST, Proc. Amer. Assoc. Adv. Sci., II, 1850, p. 60 (nomen nudum).[1]

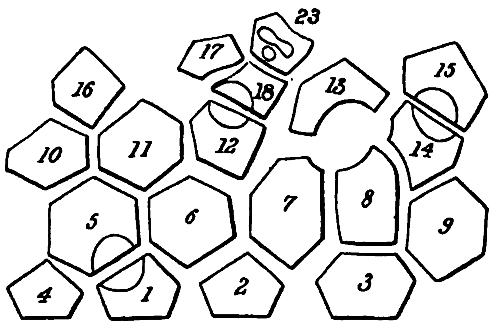


FIG. 26.—Analysis of *Tetracystis fenestratus* n. sp. (Troost).

[1] Professor Troost died August 14, 1850, about one year after his paper was read by Professor Agassiz "in the absence of the author" at the second, or Cambridge meeting, August, 1849, of the A. A. A. S. The full manuscript title of this paper, which is now in the U. S. National Museum, is "Monograph on Crinoids (?) discovered in the state of Tennessee by Dr. G. Troost." The manuscript was received by the Smithsonian Institution, July 18, 1850, and was then sent to Agassiz for revision. In Meek's letters, preserved by the Smithsonian Institution, there is one from Dr. B. F. Shumard as follows:

"New Harmony, Ind., Jan. 20, 1851.

". . . The Monograph by Troost on the Crinoids of Tennessee will probably not be published for some months yet. It is now in the hands of Agassiz and Wyman for revision."

The following is Troost's original description:

"*Echino-encrinites fenestratus*, Mihi.

"This crinoid, the summit of which is closed, and which does not possess arms, approached to the genus *Echino-encrinites* of Herman von Meyer—Cystides of von Buch, but it differs nevertheless in very important particulars from *Echino-encrinites*. The arrangement and number of plates of which it is composed are perhaps identical with those of *Echino-encrinites*. I say *perhaps*, because the five plates which form the summit, as will be seen, can not be distinguished in our fossil. The other characters by which it differs from the *Echino-encrinites* may entitle it to form a new genus.

"It has the form of a small acorn; four furrows [ambulacra] running longitudinally from the summit to the base, divide the surface into four equal parts; on three of them are poriferous rhombs and on one is an oval aperture [anus]. The poriferous rhombs are barred (these bars are not equal in number in these rhombs; some have 16, and 14 at the top, and 12 below) in the direction of the

---

In the Smithsonian Annual Report for 1853, p. 213, is the following:

"A paper has also been presented for publication by the executors of the late Dr. Troost, of Nashville. It consists of descriptions and drawings of a very numerous family of extinct zoophytes, to which the organic remains called the stone lily belong . . . and the paper of Professor Troost describes several hundred [only 107] species, of which two only have living representatives.

"The memoir, however, is not in a condition to be published without revision, and additions to bring it up to the state of knowledge at the present time. This labor has been gratuitously undertaken by Professor Agassiz, of Cambridge, and Professor James Hall, of Albany. The collection of specimens from which the drawings were made is now in the possession of these gentlemen, and the memoir will be published as soon as the corrections and additions are made."

After the paper had remained unrevised by Agassiz for five years, the manuscript was turned over to Hall, and on the cover the latter wrote "received from Professor Agassiz in Cambridge, August 23d, 1855, James Hall." Many years later Meek made inquiries at the Smithsonian Institution regarding this work, and received the following reply:

"Washington, D. C., July 21, 1868.

"My Dear Mr. Meek,
I can tell you nothing about present condition of Troost's paper or what Professor Hall has done or will do with it. Nor does Professor Henry remember anything of any plan or arrangement. We have published nothing and know of no publication. Sincerely yours,
"S. F. Baird.

"F. B. Meek,
"Springfield, Ill."

Troost's manuscript and fossils remained in Professor Hall's possession for more than forty years, and the matter was lost sight of by the Smithsonian authorities. After Professor Hall's death, the writer called the attention of smaller diagonal which gives them the appearance of venetian blinds, from which its specific name.

"The pelvis is circular with four reëntering angles, composed of four [basal] plates, three of which are pentagonal, and one, having its superior angle truncated, is hexagonal. The lower part of the pelvis terminates externally in a more or less projecting edge and then the plates turning immediately inwards form the sides of a [deep] circular excavation in which the column was inserted.

"The first [second] series of plates is composed of five; four are hexagonal, and one having upon its lower margin one [i. e., one-half] of the poriferous rhombs is rendered thereby irregular. They are placed in the four reëntering angles of the pelvis; the fifth plate is quadrilateral and rests upon the hexagonal pelvic plate, the superior of which surrounding partly the oral aperture [anus] is also thereby rendered irregular.

"The second [third] series is composed of five hexagonal plates of which three are rendered irregular by two poriferous rhombs and by the oral aperture [anus]. This oral aperture is large and circular. One of the poriferous rhombs, on the quarter section on the left of the oral aperture, occupies about one-half of an hexagonal plate; above this rhomb is an elevation, running transversely and having on its summit a furrow [the madreporite], and below it a single pore [the hydropore], neither of which penetrates through or deeply into the plate. The second poriferous rhomb is on the quarter section on the right of the oral aperture; it occupies the upper part of the third hexagonal plate, which is thus also rendered irregular.

---

the National Museum authorities to Troost's manuscript and fossils still remaining at Albany, and finally, in the month of November, 1898, the acting administrator of the Hall estate returned to Washington 294 specimens and the manuscript and drawings for 107 species. The specimens for 17 species are still missing. In the Annual Report of the National Museum for 1899, p. 39, is the following statement:

"As a matter of historical interest, it may be noted that the Troost collection of crinoidea, which, together with the manuscript describing them and drawings for 107 species, was sent by the Smithsonian Institution to Professor James Hall in 1855, was returned last November by the administrator of the Hall estate."

With very little revision, this work could well have been published in 1850, and most of Troost's species would have been saved to him. However, as it was and still is the custom of the Smithsonian Institution to refer all manuscripts submitted for publication to a committee of specialists for advice, it is very unfortunate that the work was thus allowed to fall into neglect. Since 1850 most of the species have been described, mainly by Hall, but what are left of new species will in the near future be revived. The blastoids have recently been reworked by Hambach (*Trans. St. Louis Acad. Sci.*, 1904), and the only cystid is described in this paper.

"The summit, which has no aperture, as in other species of this genus, may have been composed of five plates. But our fossil, which is very perfect, without the least erosion, being around the summit much complicated by the [ambulacral open] furrows mentioned above, which here combine, the joints of the plates being thereby obliterated, their number and form can not be ascertained.

"I can say nothing about the column,—the place where I found my specimen contained numerous fragments of different crinoids. The place of insertion of the column is very large in proportion to the size of the body, its diameter being 4 mm., while the largest diameter of the body is 10 mm. and the length 14 mm. The column was not inserted as is generally the case with crinoids. The cavity is formed of an inclined slope or bevel of about 2 mm., having no articulating striæ.

"I found this interesting fossil in Decatur county, Tennessee, associated with *Calymene Blumenbachii* [= *C. niagarensis*], *Orthoceratites, Tereb. wilsoni* [= ?*Wilsonia saffordi*], etc."

Remarks.—It is interesting to find that Troost had a species of *Tetracystis* more than 50 years ago, which he then referred to *Echinoencrinites.* It is closely related to the Manlius *T. chrysalis,* but differs in being smaller, more circular in transverse outline, and not flattened as is that species; the pectinirhombs, also, have far fewer dichopores. In *T. fenestratus* there are 12 to 17 pores, and in *T. chrysalis* from 25 to 35. Of brachioles the former has from 7 to 8 on each side of an ambulacrum, while the latter species has 11 in the same space. Plate 19 and deltoid 24 may not be present in *T. fenestratus;* if they are, they are now obscured by the ambulacralia. However, as Troost's species is otherwise closely related to *T. chrysalis,* it is probable that other specimens may reveal these two small plates.

Formation and locality.—The horizon in Decatur county, Tennessee, furnishing this fossil, appears to be the Brownsport limestone of Foerste, formerly a part of Safford's Meniscus limestone, in the upper portion of the Niagaran.

Cat. number 35,091, U. S. N. M.

Jaekelocystis Schuchert

Jaekelocystis SCHUCHERT, Amer. Geol., XXXII, 1903, p. 230.

Definition.—Apiocystinæ with the theca pyriform or globular in outline, rounded oval or 4-sided in transverse section, and composed of 18 plates, which are arranged as follows:

Basal row has plates 4, 1, 2, 3.
Second row has plates 5, 6, 7, 8, 9.
Third row has plates 10, 11, 12 (7, 8), 14.
Fourth row has plates 16, 17, 18, 13 (19 absent), 15.
Fifth row has deltoid 23.

Deltoid 23 is a very small plate situated at the top of plate 18 and between it and plate 13. It has a comparatively large hydropore, but a madreporite does not seem to be present. Plate 19 of other genera is not developed in this genus. Anal area small but conspicuous and protruding, consisting only of the pyramid of 6 pieces. The prominence of the anal area is due to the protrusion of the bounding thecal plates of which there are 4, i. e., 7, 8, 13, and 14. One basal and 2 upper very small discrete-pectinirhombs. The parts on plates 1, 12, and 14, as a rule, do not show the dichopores, since these are deeply situated each in a pit with a high margin. Dichopores few.

Ambulacra normally 4 in number. These are R I, R V, R IV, and R II. In rare cases, either R I or R II may be absent, or R V may be forked. Ambulacra depressed, more or less deeply excavated, and, in normal individuals, continuing to or near to the column. Brachioles moderately abundant, short and stout.

Column comparatively stout. Length unknown.

Genotype, *J. hartleyi* Schuchert.

Jaekelocystis seems to have closest relationship with *Apiocystites* and therefore, also, with *Lepocrinites*. It is readily distinguished from these genera in that it has but 18 thecal plates, plate 19 not being developed. The same difference is found when *Jaekelocystis* is compared with *Staurocystis*. Even should plate 19 be present as a very minute piece, this genus would still differ from *Apiocystites* and *Lepocrinites* in that its third row of thecal plates has but 4, while in the latter genera it has 5, plates. In other words, in these two genera plate 13 is in the third row, while in *Jaekelocystis* it is in the fourth. Another difference distinguishing this genus from all other associated cystids with 4 simple ambulacra lies in the composition of the anal area, which consists only of the pyramid of 6 pieces. In the other genera there is always an additional circle of small pieces. Moreover, in *Apiocystites* and *Lepocrinites* this area is bounded by plates 7, 8, and 13, while in *Jaekelocystis* there are 4 plates—7, 8, 13, and 14.

Tetracystis also has 4 ambulacra and but 4 plates in the third circle of the theca. However, it differs from *Jaekelocystis* in having plate 19, and therefore has 6 plates in the fourth circle of the theca. Further, the anal area has a circle of plates around the pyramid, the pectinirhombs are large with the halves adjoining, and the brachioles few in number and widely separated.

The genus is named for Doctor Otto Jaekel of the Geological Institute of the Friedrich-Wilhelms University, Berlin, Germany, in recognition of the great service he has rendered to paleontology by his detailed description of the *Thecoidea* and *Cystoidea*, forming volume I of his great contemplated work on the *Stammesgeschichte der Pelmatozoen*. This work has been of the greatest aid in the present studies, and in the accuracy of their results.

JAEKELOCYSTIS HARTLEYI Schuchert

(PLATE XXXVII, FIGURES 4-8)

Jaekelocystis hartleyi SCHUCHERT, Amer. Geol., XXXII, 1903, p. 231.

Length of a full-grown theca 15 mm.; width and depth about 11 mm. For general form, shape of individual plates and their ornamentation, see the figures and diagram, figure 27.

Ambulacra narrow, excavated into, and but slightly elevated above, the theca, and in normal specimens extending to the column. Each pair of ambulacra, or R I and R II, R IV and R V, converging and almost touching each other near the column. In one individual, R I is but half the normal length and R II is almost aborted, having but 6 brachioles. In another individual R I is entirely undeveloped, while in a third specimen R II is absent. In a fourth specimen R V is forked, the branch developing on the left. In full-grown specimens, there are about 34 brachioles to each ambulacrum, 17 on either side. Brachioles stout and folded over each other medially; length unknown but apparently quite short. Ambulacral grooves narrow and shallow, with very minute ambulacralia.

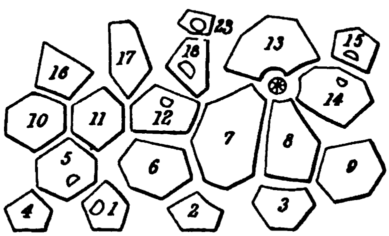


FIG. 27.—Analysis of *Jaekelocystis hartleyi* Schuchert.

Dichopores on plates 1, 12, and 14 not shown at the surface, being deeply situated within small oval pits, each with a rim highly elevated above the surface of these plates. Those on plates 5, 18, and 15 show the dichopores with the excavation deepest orally, and are here delimited by a crescentic lip. About 8 folds in each rhomb.

Hydropore conspicuous, situated on a small piece (plate 23), placed above and between plates 18 and 13. No madreporite discernible. For detail of this region and the ambulacra, see figure 6, plate XXXVII.

Anal pyramid small, not strongly elevated, composed of 6 pieces, but made quite prominent by the protrusion of the bounding margins of thecal plates 7, 8, 13, and 14.

Column comparatively stout, and, as is usual in cystids, composed of thick segments near the theca. Length unknown.

Comparisons.—This beautiful, regular, but small cystid is readily distinguished from the other species of *Jaekelocystis* by the pyriform outline, strong sculpturing, and the more prominent ambulacra. *J. papillatus* is also easily identified by the much finer papillose ornamentation.

Formation and locality.—A very common species in the quarries and elsewhere near Keyser, West Virginia, many hundred examples having been seen. The first specimen was dug up near Judge Alkire's house by Mr. Frank Hartley of Cumberland, Maryland. It is found associated with *Sphærocystites multifasciatus*, *S. globularis*, and *Pseudocrinites gordoni*, these four being the common species of the cystid beds of the lower Manlius formation about Keyser. It gives the writer pleasure to name this species for its discoverer, in recognition of his enthusiasm and untiring efforts in the unearthing of many new Siluric and Devonic species of western Maryland.

Cat. number 35,055, U. S. N. M.

JAEKELOCYSTIS PAPILLATUS n. sp.

(PLATE XXXVII, FIGURES 9, 10)

Length of the largest theca 15 mm.; width and depth 12 mm. For general form and sculpturing, see plate XXXVII, figures 9, 10.

Anal area less prominent than in the other species of this genus, and bounded by plates 7, 8, 13, and only a very small part of 14.

This species differs from *J. hartleyi*, to which it is closely related, in the more globular theca, fewer brachioles, absence of grooves along the suture lines of the plates and the papillose sculpturing of the plates; also in the fact that the discrete halves of the pectinirhombs are alike and not with one-half buried deeply in a pit with a high rim. Each ambulacrum has from 11 to 12 brachioles on each side, while in *J. hartleyi* there are 17 in the same length. The pectinirhombs likewise have more dichopores, there being from 12 to 15 in each, while in *J. hartleyi* there are only about 8.

Formation and locality. Only two specimens of this species are known from the quarries near Keyser, West Virginia.

Cat. number 35,057, U. S. N. M.

JAEKELOCYSTIS AVELLANA n. sp.

(PLATE XXXVII, FIGURES 11, 12)

Theca shaped like a hazelnut, the resemblance suggesting the name, about 10 mm. in length and breadth, in the largest of three known examples. Plates nearly smooth; for their individual form, see the diagram (figure 28) and plate XXXVII, figures 11, 12.

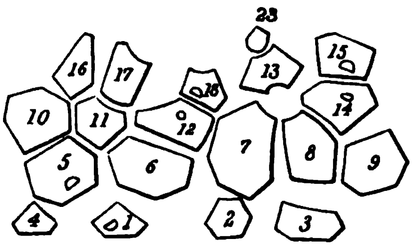


FIG. 28.—Analysis of *Jaekelocystis avellana* n. sp.

Ambulacra narrow, but appearing wide on account of their lying in rather deeply excavated thecal grooves, with sharply elevated margins, extending to the lower ends of the second or to the top of the basal circle of thecal plates. The 4 ambulacra are regularly disposed and do not converge. Nature of brachioles unknown, about 26 on each ambulacrum, or 13 on each side. Ambulacrals thick, causing the ambulacral furrow to be narrow; ambulacralia not preserved.

Hydropore conspicuous and situated as in *J. hartleyi*.

Anal pyramid not preserved. Anal area less conspicuous, but otherwise as in *J. hartleyi*.

Pectinirhombs as in the species just cited, with 1 or 2 dichopores less to each rhomb.

Column unknown.

Formation and locality.—Three specimens of this species are known from the cystid beds of the Manlius in the quarries near Keyser, West Virginia. One of these is in Mr. Hartley's collection.

Cat. number 35,056, U. S. N. M.

Subfamily STAUROCYSTINÆ Jaekel

Callocystidæ with the brachioles closely adjoining, and the ambulacra highly arched and prominent. Ambulacra 2, 3, or 4 in number, and never bifurcating.

Pseudocrinites Pearce

Pseudocrinites PEARCE, Proc. Geol. Soc. London, IV, 1843, p. 160.—FORBES, Mem. Geol. Surv. Great Britain, II, pt. II, 1848, p. 494.—JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 283, fig. 60 on p. 284.

Pseudocrinus HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 135.—BATHER, Treatise on Zoology, III, Echinoderma, London, 1900, p. 62, fig. 29.

The Cystidea were not separated from other Echinoderma until 1844, by von Buch; a year earlier, however, Pearce defined the genus *Pseudocrinites* as follows:

"Mr. Pearce regards them as constituting a new genus which he proposes to name *Pseudocrinites,* including two species both having the arms [ambulacra] and fingers [brachioles] inserted in hands, which commence just above the column and pass over the plates of the head to its summit. The one form has two [now accepted as the genotype], the other four ranges of fingers [*Staurocystis*]. They resemble each other in having the columns at their superior part composed of rings, gradually increasing in size towards the head. The plates of the head are thin and broad, and marked on their outer surface by lines of growth, and radiating ridges resembling the plates of the marsupite. They are also furnished with four orifices [pectinirhombs. Seeing two on one side he concluded there were four in all, but there are only three] of a lozenge shape, most singularly inserted in the plates of the head, and their arms and fingers are exceedingly short. The fingers [brachioles] are composed of two rows of bones [plates], each bone on the one side being inserted between two of the opposite. These fingers appear to be placed in four rows [should be two rows on each ambulacrum] on each of the hands, and pass off from the head in a radiating direction, commencing at the column and uniting at the summit. Mr. Pearce names the first species *Pseudocrinites bifasciatus* [the genotype selected by Haeckel], and the second *P. quadrifasciatus* [selected by Haeckel as the genotype of *Staurocystis*]."

Emended definition of Pseudocrinites.—Staurocystinæ with the sides of the theca compressed, varying in outline from circular to elongate subquadrate, and composed of 19 plates. These are arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6, 7, 8, 9.

Third row has plates 10, 11, 12, 14.

Fourth row has plates 16, 17, 18, 13, 19, 15.

Fifth row has deltoid 23.

Deltoid 23 is very small, situated between the ambulacra on the left oral side of plate 18, with the hydropore and madreporite present. Hydropore closed by a pyramid of 5 plates. Anal area small, placed between plates 7, 8, 13, and 14, and consisting of an outer complete or incomplete circle of from 6 to 8 pieces and the pyramid of 7 pieces. One basal and 2 upper pectinirhombs normally situated, with long, angulated, grooved, adjoining recesses, and numerous dichopores.

Ambulacra 2 in number, apparently R I and R IV (see remarks on *Trimerocystis*). These extend along the narrow periphery of the theca and in most species touch the column. Brachioles abundant. The piece with the madreporite and a depression diagonally opposite separates the 2 ambulacra.

Column stout near the theca, tapering more or less rapidly, and composed of equal-sized pieces with angulated margins. Beneath this upper section the column maintains a nearly equal diameter, and the pieces may be interspersed with larger ones, all having a rounded periphery.

Genotype, *P. bifasciatus* Pearce. The above diagnosis, however, is based on *P. gordoni*. Of the former there is a specimen in U. S. N. M.; cat. number 35,138.

Pseudocrinites is readily distinguished from the other Siluric genera of cystids by the fact that it has but 2 ambulacra, sometimes called recumbent arms. In all other associated genera there are 3 or 4 of these arms.

The number and arrangement of the thecal plates are the same in all species (except *P. abnormalis*). The specific characters are form, arrangement of anal plates, length of ambulacra, number and length of brachioles, nature of ambulacralia, and number of dichopores. On the basis of these characters, eight new species are here described. To facilitate easy reference, these forms and their specific features are tabulated as follows:

TABLE OF CHARACTERS OF AMERICAN SPECIES OF PSEUDOCRINITES. (BASED ON AVERAGE-SIZED OR FULLY ADULT SPECIMENS)

Group of *P. gordoni*

Circular in outline. Ambulacra extending to the column. Anal area composed of 1 outer complete circle of pieces and an inner pyramid.

	Length	Width	Brachioles	Folds in Pectinirhomb		
				1–5	12–18	14–15
P. gordoni.........	31 mm	29 mm	160	80	90	120
P. abnormalis....	29 "	22 "	135	65	70	70
P. claypolei........	19 "	19 "	56	26	32	42
P. stellatus.........	25 "	23 "	72	60	80	90

Group of *P. clarki*

Elongate in outline. Ambulacra extending to the column. Anal area composed of an apparently incomplete outer circle of pieces and an inner pyramid.

	Length	Width	Brachioles	Folds in Pectinirhomb		
				1–5	12–18	14–15
P. clarki..........	30 mm	22 mm	88	42	50	68
P. subquadratus..	16 "	12 "	52	33	33	43
P. elongatus.......	40 "	23 "	84	65	75	110

Group of *P. perdewi*

Pear-shaped in outline. Ambulacra occupying less than two-thirds of the periphery of the theca. Anal area as in the *P. gordoni* group.

	Length	Width	Brachioles	Folds in Pectinirhomb		
				1–5	12–18	14–15
P. perdewi	57 mm	39 mm	90	82	114	148

Of foreign species of *Pseudocrinites,* there are but two—*P. bifasciatus* Pearce and *P. magnificus* Forbes—and these are of the *P. gordoni* group. Forbes states that the former has 12 to 16 brachioles on each ambulacrum, but this number apparently includes only those of one edge, as is shown by his figure 3 of plate XI. The total number of brachioles in this species appears, therefore, to be from 48 to 64 (Jaekel gives about 80). *P. bifasciatus* is consequently closely related to *P. claypolei* and *P. stellatus,* but in both of the latter the pectinirhombs are much more pronounced. *P. magnificus* is somewhat larger than *P. gordoni,* and has about 136 brachioles (Jaekel gives 100 to 120), but differs from American species in the smaller pectinirhombs and the different thecal ornamentation. Both these English species occur in the Siluric near Dudley; *P. bifasciatus* in the Wenlock limestone, and *P. magnificus* in the same horizon and in the Lower Ludlow.

PSEUDOCRINITES GORDONI Schuchert

(Plate XXXVI, figures 8–12; Plate XXXIX, figures 11–13)

Pseudocrinites gordoni Schuchert, Amer. Geol., 1903, XXXII, p. 235.

Length of the largest theca 32 mm.; greatest width 32 mm.; depth 21 mm. For general form, shape of individual plates and their ornamentation, see the figures and diagram, figure 29.

Ambulacra angularly elevated, prominent, extending around the entire periphery of the theca, and touching the column in specimens 20 mm. or more in length. In some of these mature specimens the ambulacra, when near the column, are deflected, and one or both will pass on the same side for a short distance in front of it. In smaller specimens the ambulacra do not quite reach the column, and in one having a thecal length of 15 mm. they stop within 3 mm. of the stalk. In the largest specimen there are 40 brachioles on each side of an ambulacrum, while in one having a thecal length of 15 mm. there are about 21. Length of brachioles not definitely known; those of the apical region not less than 11 mm., stout, and with about 17 pieces in each column. Ambulacral groove wide and covered by a complex series of small and large ambulacralia arranged as shown in figure 11 of plate XXXIX.

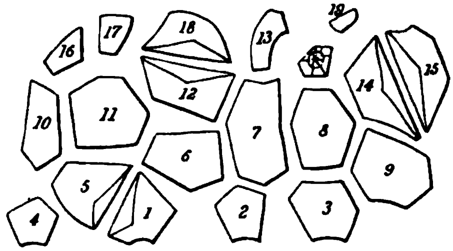


FIG. 29.—Analysis of *Pseudocrinites gordoni* Schuchert.

Basal pectinirhomb smallest, in the largest specimen having about 80 grooves; that on plates 12 and 18 has about 90, and the one on plates 14 and 15 is the largest, with about 120.

Hydropore minute, closely adjoining the madreporite.

Anal pyramid depressed, consisting of 7 somewhat ornamented plates surrounded by a circle of 8 larger plates of irregular size and definite sculpture.

Column slender. Length unknown.

Comparisons.—*P. gordoni* is the most prolific of American *Pseudocrinites*. The nearly circular outline of the theca and the greater number of brachioles distinguish this species from *P. clarki* and *P. perdewi*. Of forms with nearly circular theca *P. stellatus* differs in the very prominent sculpturing and the smaller number of brachioles, while *P. claypolei* differs in the vermiform sculpturing and fewer brachioles.

P. gordoni undergoes but little modification in form. In general the outline is circular, but occasionally a specimen is a little more elongate and in rare cases one is more transverse. Of the latter, one has a thecal length of 29 mm.; breadth 33 mm.; and depth 19 mm. There is very little abnormal material. One specimen has the ambulacrum R IV abutting against the lower pectinirhomb instead of passing to the left of it. In another basally compressed individual, both ambulacra are bowed toward the anal side, particularly R IV, causing the opposite side of the theca to be more convex and almost angulated on the left.

Formation and locality.—Common in the Keyser quarries, where it was first collected by Robert H. Gordon of Cumberland, Maryland. The species is named for its discoverer in recognition of the very valuable services he has rendered, not only as an enthusiastic collector, but also as a careful student of the complicated geology of western Maryland.

Cat. number 35,071, U. S. N. M.

PSEUDOCRINITES ABNORMALIS n. sp.

(PLATE XXXV, FIGURES 10-12)

Length of the only specimen 29 mm.; width 22 mm.; depth 14 mm. For general form, shape of individual plates and their ornamentation, see the figures and diagram, figure 30.

Pectinirhombs about equally large and each has from 65 to 70 folds. Basal pectinirhomb on plates 5 and 6 and not, as usual in this genus, on plates 1 and 5. In other words, this pectinirhomb is confined to the second circle of plates and is not divided, one-half of the rhomb being in the basal and the other half in the second row.

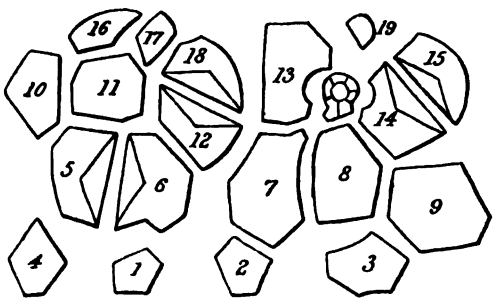


FIG. 30.—Analysis of *Pseudocrinites abnormalis* n. sp.

Ambulacra as in *P. gordoni,* with about 34 brachioles on one side of each ambulacrum.

Comparisons.—This species has the general expression of *P. gordoni,* except that the outline of the theca is regularly oval instead of nearly circular. It differs, also, in having the basal pectinirhomb on plates 5 and 6 instead of on plates 1 and 5. That the two forms are really closely related is shown by the arrangement of the anal plates. In *P. abnormalis,* as in *P. gordoni,* these are composed of 2 complete circles of plates, while in the group typified by *P. clarki* the outer circle consists of plate 13 and several small pieces restricted to the posterior half. Because of this close resemblance the writer regards the present specimen as abnormal in development, or a monstrosity, but thinks it best to give it a name, for easy reference. Were it not for the very close identity in all specific characters save the abnormal position of the basal pectinirhomb, one would be led to distinguish *P. abnormalis* as the genotype of a new genus. That the position of the basal pectinirhomb is abnormal is shown by the shape of plate 1, but especially by plate 6, which is notched to receive all the anterior edge of plate 1.

Formation and locality.—The holotype was found by the writer, associated with *P. gordoni,* in the quarries near Keyser, West Virginia.

Cat. number 35,068, U. S. N. M.

PSEUDOCRINITES CLAYPOLEI n. sp.

(PLATE XXXVII, FIGURE 1)

Length and width of the only specimen at hand 19 mm.; thickness about 12 mm. For form and ornamentation, see figure 1, plate XXXVII.

The ambulacra extend around the entire periphery of the theca and touch the slender column. All plates of the ambulacra and the brachioles are gone, but the impressions left by the former indicate that about 14 brachioles existed on either side of each ambulacrum.

Basal pectinirhomb with 26 dichopores, that on plates 12 and 18 has 32, and on plates 14 and 15 about 42.

Comparisons.—That this species is related to *P. gordoni* and *P. stellatus* is shown by the lens-shaped theca; it differs from the former in having fewer brachioles and in the vermicular sculpturing, while the latter species has the plates marked by a few strong radiating ridges.

Formation and locality.—In the lower portion of the Manlius at Clark's Mills, near New Bloomfield, Pennsylvania, associated with *Sphærocystites bloomfieldensis.* The writer's attention was directed to this locality on reading an account of it in *Report FF* of the *Second Geological Survey of Pennsylvania* (p. 182), by the late Professor Edward W. Claypole, for whom this species is named.

Cat. number 35,066, U. S. N. M.

PSEUDOCRINITES STELLATUS Schuchert

(PLATE XXXV, FIGURES 8, 9; PLATE XXXIX, FIGURE 7)

Pseudocrinites stellatus SCHUCHERT, Amer. Geol., XXXII, 1903, p. 236.

Length of a large specimen 25 mm.; breadth 23 mm.; depth about 15 mm. Mr. Hartley has a specimen 32 mm. long and 30 mm. wide. For form of theca and its sculpturing, see figure 7, plate XXXIX.

Ambulacra well defined, flat topped, extending around the entire periphery of the theca and touching the column. Ambulacrals large. Each ambulacrum in full-grown specimens has about 36 brachioles; in a small specimen having a thecal length of 15 mm., there are but 24 brachioles. Brachioles usually not preserved. Ambulacral groove wide, roofed by a median double row of tiny angular ambulacralia arranged in short crescents, and outside of these by a single row of much larger, strongly elevated plates, each one of which is as large as two of the ambulacrals. For detailed structure, see figure 7, plate XXXIX.

Basal pectinirhomb with about 60 dichopores, that of plates 12 and 18 with 80, and of 14 and 15 with 90.

Madreporite quite large for *Pseudocrinites,* but the hydropore is exceedingly minute.

Anal area small, composed of 2 circles of plates; the outer has 7 nodose pieces and the inner depressed pyramid has the same number of plates.

Column slender, but its length is unknown.

Comparisons.—This species is readily distinguished from all other *Pseudocrinites* by the strongly stellate sculpturing of the plates. *P. gordoni* differs further in having many more brachioles.

Formation and locality.—Of this species three specimens are in the U. S. National Museum, seven in Mr. Hartley's collection, and two in Mr. Gordon's. All are from the quarries near Keyser, West Virginia.

Cat. number 35,069, U. S. N. M.

PSEUDOCRINITES CLARKI Schuchert

(PLATE XXXVI, FIGURES 4–7; PLATE XXXIX, FIGURE 14)

Pseudocrinites clarki SCHUCHERT, Amer. Geol., XXXII, 1903, p. 237.

Length of largest theca 44 mm.; greatest width 30 mm.; depth 22 mm. Length of an average specimen 30 mm.; greatest width 22 mm.; depth about 16 mm. For general form, shape of plates and their ornamentation, see figures 4–6, plate XXXVI.

Ambulacra in mature specimens very prominent, triangular in transverse section, extending around the entire periphery of the theca and touching the column. In the second largest individual each ambulacrum had about 44 brachioles, in another mature but smaller specimen there were only 32. Brachioles unknown, apparently more slender than in *P. gordoni.* Ambulacral grooves narrow, and covered by highly elevated ambulacralia of about the same nature as in *P. gordoni,* but less numerous and the larger plates more nodose.

Basal pectinirhomb in the specimen of average size above mentioned, with about 42 dichopores, that of plates 12 and 18 with about 50, and that of plates 14 and 15, which is the largest, with about 68. In the largest specimen there are as many as 120 in a rhomb.

Hydropore minute and closely adjoining the rather large and prominent madreporite, situated, as usual in *Pseudocrinites,* laterally between the ambulacra on the edge of plate 23.

Anal area well marked, consisting of 2 circles of plates. The outer circle has 4 small plates in the right posterior corner, and these are followed on the left by 3 very much smaller pieces. The latter are not readily seen, and the first impression is that the 4 pieces of the right posterior corner and plate 13 complete the circle. The prominent anal pyramid has 7 triangular pieces.

Column stout, composed of thick pieces near the theca. Length unknown.

Comparisons.—This species differs from other *Pseudocrinites* having ambulacra extending to the column, in its regularly oval outline. *P. subquadratus* is a much smaller species, subquadrate in outline, and with different thecal sculpturing. *P. elongatus* is more elongate subquadrate.

Formation and locality.—Of this species the U. S. National Museum has eleven specimens, the Geological Survey of Maryland one, Mr. Gordon two, and Mr. Hartley ten. All are from the quarries near Keyser, West Virginia. It gives the writer pleasure to name this species for Dr. William Bullock Clark, the distinguished geologist and paleontologist, and the director of the Maryland Geological Survey.

Cat. number 35,070, U. S. N. M.

PSEUDOCRINITES SUBQUADRATUS n. sp.

(PLATE XXXV, FIGURES 4, 5)

Length of the only known specimen 16 mm.; width 12 mm.; depth 9 mm. The base of the theca is comparatively large, indicating a stout column; the oral end is flattened. Between the two flattened ends the theca is slightly convex, giving it the subquadrate outline indicated by the specific name. The sculpturing of the thecal plates is decidedly vermicular, and not radiate as in most other species.

Ambulacra prominent, rounded on the top, extending to the column, composed of 26 comparatively stout basement plates bearing 13 brachioles on one side of each ambulacrum. Brachioles short, very slender, about 5 mm. long, and having about 10 plates in each column. Ambulacral groove large. Ambulacralia not preserved.

Pectinirhombs on plates 1 and 5, 12 and 18, about equally large and having about 33 dichopores, while that on plates 14 and 15 is largest and has 43.

Madreporite prominent, situated as usual on plate 18; the hydropore is very minute.

Anal area as in *P. clarki,* prominent, consisting of 2 circles of pieces, the outer one made up of 4 or 5 right posterior plates, 3 minute pieces on the left, and plate 13. The inner pyramid is not preserved in the specimen at hand.

Comparisons.—This species is most closely related to *P. elongatus,* but the greater size and elongated theca of the latter will readily distinguish it. *P. clarki* is similar, but the greater size, oval outline, and the differently sculptured plates will serve to identify it.

Formation and locality.—The only specimen known was found by Mr. Hartley at Devil's Backbone, opposite Corringansville, near Cumberland, Maryland. The horizon is in the upper portion of the Manlius or the lower half of zone "D. B. Ba." of the section described by the writer on p. 418, *Proceedings of the U. S. National Museum,* 1903.

Cat. number 35,067, U. S. N. M. Presented by Mr. Robert H. Gordon.

PSEUDOCRINITES ELONGATUS n. sp.

(PLATE XXXV, FIGURES 6, 7)

Oral end of the only specimen broken away, but the length seems to have been about 40 mm.; width 23 mm.; depth 17 mm. For general form and shape of individual plates, see figures 6, 7, plate XXXV, and text-figure 31.

Ambulacra prominent, extending around the entire periphery of the theca and touching the column. As the top of the theca is broken away, the exact number of brachioles cannot be counted, but, on the basis of brachioles preserved and the close relationship to *P. subquadratus,* the total number on each side of an ambulacrum is estimated to be between 26 and 28. Ambulacral groove large and deep; ambulacralia not preserved.

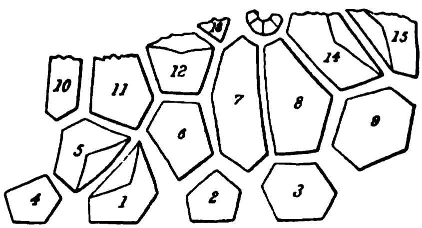


FIG. 31.—Analysis of *Pseudocrinites elongatus* n. sp.

Basal pectinirhomb has about 65 dichopores, that of plates 12 and 18 about 75, and of plates 14 and 15 about 110.

Comparisons.—As the various forms of *Pseudocrinites* are easily recognized on account of their constant characters, the writer does not hesitate to describe this broken specimen as a new species. Its greatly elongate, narrow form distinguishes it from all the others. *P. elongatus* is closely related to *P. subquadratus,* as both have the same general form, size of ambulacral plates, and sculpture, but the former is readily separated by being more elongate with the sides of the theca straighter, and more especially by the far greater size, being 2½ times larger than *P. subquadratus.*

Formation and locality.—The holotype was found by Mr. Perdew in the Manlius formation on Martin's mountain, near Lodger Perdew's farm in Pleasant valley, Bedford county, Pennsylvania.

Cat. number 35,065, U. S. N. M.

PSEUDOCRINITES PERDEWI Schuchert

(PLATE XXXVI, FIGURES 1–3; PLATE XXXIX, FIGURES 8–10)

Pseudocrinites perdewi SCHUCHERT, Amer. Geol., XXXII, 1903, p. 238.

The four following specimens represent four stages in the growth of this species:

	Length	Width	Depth	Brachioles (total)	Rhomb 1–5	Rhomb 12–18	Rhomb 14–15
Specimen 1	16 mm	11 mm	9 mm	23	20 dichop.	34 dichop.	40 dichop.
Specimen 2	24 "	17 "	12 "	48	42 "	48 "	58 "
Specimen 3	35 "	27 "	15 "	76	53 "	65 "	82 "
Specimen 4	57 "	39 "	?20 "	90	82 "	114 "	148 "

General form pear-shaped, with the sides appressed. For shape of the individual plates and their ornamentation, see the diagram and plate-figures.

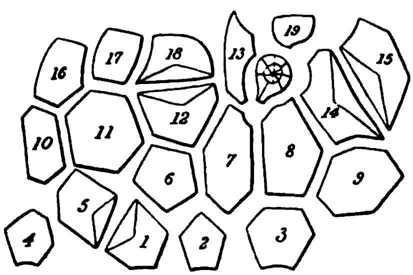


FIG. 32.—Analysis of *Pseudocrinites perdewi* Schuchert.

Ambulacra wide, very prominent, with vertical angulated sides and flat or slightly trough-shaped oral surfaces. In specimen number 1, the 2 ambulacra taper rapidly and extend along the periphery of the theca for one-third its length. In number 2, they are just one-half the length of the theca, in number 3 nearly two-thirds the length, while in number 4 they are about one-half the length. This shows that the length of mature ambulacra is somewhat variable, extending from one-half to two-thirds the thecal length. The ambulacrum nearest the anal region is always somewhat shorter. Number of brachioles on one side of each ambulacrum varying with age, there being in the youngest known specimen (no. 1) about 5, in a mature individual (no. 3) about 19, and in the largest example (no. 4) about 22. Ambulacral grooves narrow in comparison with the large size of the ambulacrals, and covered by very small rectangular ambulacralia which are sharply elevated into a median ridge. There are usually from 10 to 12 ambulacralia to each ambulacral, but in different specimens the number varies. The branches going to the brachioles at the lateral ends of the plates have the ambulacralia as well developed as the median series. Brachioles slender, composed of rather large, elongate, smooth pieces. Those at the distal ends of the ambulacra have 6 pieces in a column 4 mm. long; seemingly these brachioles did not exceed 12 mm. in length.

Anal area small, not prominent, and composed of 2 circles of plates. The outer circle has from 7 to 9 pieces of unequal size, and the flat pyramid has 7 or 8 equal triangular pieces.

The madreporite is rather large for *Pseudocrinites,* but the hydropore is minute, and both are placed within a distinct hollow separating the ambulacra of one side.

Basal pectinirhomb smallest, that of plates 14 and 15 largest.

Column slender, tapering rapidly for a short distance from the theca, and composed of pieces of equal thickness. Length unknown.

Comparisons.—This splendid large and odd *Pseudocrinites* is readily distinguished from all other species of the genus by the short, high, and angulated ambulacra. The form of the theca and the plate sculpturing are also characteristic.

Formation and locality.—Of this form the National Museum has five excellent examples, the Geological Survey of Maryland one, Mr. Gordon one, and Mr. Hartley twelve. All are from the cystid beds of the Manlius in the quarries near Keyser, West Virginia. The specific name is given in recognition of the assistance rendered the writer by Mr. George M. Perdew of Cumberland, Maryland.

Cat. number 35,072, U. S. N. M.

Trimerocystis n. gen.[1]

Generic characters.—Staurocystinæ having the general structure of *Pseudocrinites,* but differing in having 3 ambulacra instead of 2; these are as long as the theca, and are R I, R IV, and R V. Another

[1] The generic name has reference to the tripartite divisions of the ambulacra in this cystid.

difference is that whereas plates 10 and 16 in *Pseudocrinites* are situated in the third and fourth rows, in *Trimerocystis* they have passed one circle lower, being, respectively, in the second and third rows. In tabular form the 4 rows of 19 thecal plates in these genera are arranged as follows:

	Basal Circle	Circle 2	Circle 3	Circle 4
Pseudocrinites	4-1-2-3	5-6-7-8-9	10-11-12-14	16-17-18-13-19-15
Trimerocystis	4-1-2-3	10-5-6-7-8-9	16-11-12-14	17-18-13-19-15

Madreporite and hydropore as in *Pseudocrinites.*

Genotype, *T. peculiaris* n. sp.

Comparisons.—The 3 long ambulacra readily distinguish *Trimerocystis* from all other related genera, as they have either 2 or 4 simple, or 4 variously branched ambulacra.

In determining what 3 ambulacra of the 5 of a primitive cystid are present in *Trimerocystis,* the writer has relied on the assumption that R III is always absent in forms having 4 ambulacra, as *Tetracystis, Lepocrinites,* etc. This view seems to be correct, since in all 4-armed cystids described in this paper, there is no ray directly opposite the anus. In *Pseudocrinites* Jaekel identifies the 2 ambulacra as R II and R V; Bather does the same, except that he names them "apparently right posterior and left anterior." If this interpretation is correct, then the third ambulacrum, or the one just to the right of the anal area, in *Trimerocystis* should be R IV or the right anterior ray, thus placing the anal area between R V and R IV, which is of course anomalous and highly improbable. It is certain that the ambulacrum to the left of the anal area in *Trimerocystis* is the same as R II in *Pseudocrinites;* also that the one passing anteriorly in the former genus is equal to R V of the latter—an interpretation also made by both Jaekel and Bather. This is further shown in the specimen of *Trimerocystis* in which the 2 corresponding ambulacra are continuous, and directly in line and opposite to each other as in *Pseudocrinites.* Not only so, but the madreporite, and pectinirhombs 1 and 5, and 12 and 18, are to the left of these ambulacra, while the anal area and pectinirhombs 14 and 15 are to the right in both genera. The third ambulacrum in *Trimerocystis* is also to the right. If this third ambulacrum is not altogether anomalous, then it may be stated that the 2 ambulacra placed one on either side of the anus represent the bivium or rays I and V. As the anterior ray does not hold the central line opposite the bivium, one is seemingly forced to conclude that it represents R IV. With this interpretation the 2 ambulacra in *Pseudocrinites* should represent R I and R IV. Moreover, the madreporite, hydropore, and pectinirhombs 1 and 5, and 12 and 18, in *Trimerocystis* will then lie between R I and R IV, and pectinirhombs 14 and 15 between R V and R IV. The three following diagrams will make this correlation more clear:

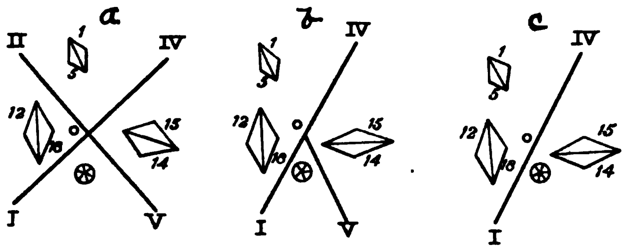


FIG. 33.—Diagram showing relation of ambulacra in (*a*) *Tetracystis*, (*b*) *Trimerocystis*, and (*c*) *Pseudocrinites*.

For these reasons the writer has changed the nomenclature of the rays in *Pseudocrinites* from R II and R V to R I and R IV.

Though *Trimerocystis* is based on a single specimen, having obvious relations to *Pseudocrinites clarki*, it cannot be regarded as a monstrosity of that species, because the two forms do not occur in the same bed. *Trimerocystis peculiaris* was not found in the cystid horizon at Keyser, but above it (probably less than 10 feet), in association with *Camarocrinus*, and is the only known cystid in this zone. Under these circumstances, and in order that the generic definition of *Pseudocrinites* may stand, the writer has deemed it advisable to erect a new genus for this 3-rayed type.

TRIMEROCYSTIS PECULIARIS n. sp.

(PLATE XXXV, FIGURES 1–3)

Length of theca 35 mm.; width 26 mm.; depth 20 mm. Base of theca deeply excavated and occupied by a stout column. For general form, shape of individual plates and their ornamentation, see figures 1–3, plate XXXV, and text-figure 34.

Ambulacra prominent, rounded, extending along three sides, bent around the excavated base of the theca, and touching the column. Each ambulacrum has on one side about 30 brachioles, or 60 to each ray, and about 180 on the entire theca. Brachioles apparently not very stout nor long, and composed of rather large pieces. Ambulacral grooves narrow, but deep, and covered by a series of small ambulacralia arranged much as in *Pseudocrinites perdewi*, with the pieces somewhat larger.

Basal pectinirhomb and that on plates 12 and 18, each with about 75 dichopores, and that on plates 14 and 15 with about 110.

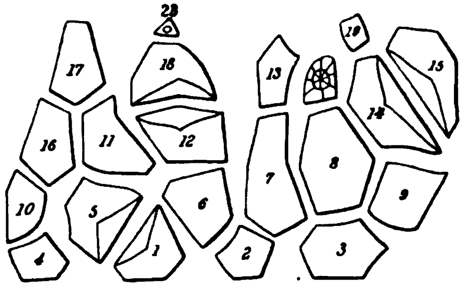


FIG. 34.—Analysis of *Trimerocystis peculiaris* n. sp.

Madreporite large and the hydropore immediately in front of it somewhat larger than in *Pseudocrinites.* Both are situated on plate 23.

Anal pyramid composed of 7 pieces, and surrounded by another circle of larger pieces of which there appear to be 7 or 8. The anal area lies between plates 7, 8, 13, and 14.

Column very stout. Length unknown.

Formation and locality.—From bed 4 (see page 203) of the Manlius formation in the Keyser quarries, associated with *Camarocrinus, Tentaculites gyracanthus,* and *Calymmene camerata.* The holotype was found by Mr. Joseph Gambino, foreman in the quarries.

Cat. number 35,064, U. S. N. M.

Staurocystis Haeckel

Pseudocrinites FORBES (partim), Mem. Geol. Surv. Great Britain, II, pt. II, 1848, p. 498, pl. xiii, figs. 1–13.

Staurocystis HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 134.—JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 285.

Lepadocrinus BATHER (partim), Treatise on Zoology, III, Echinoderma, London, 1900, p. 61.

Haeckel's definition, translated, is as follows: "Callocystida with 4 simple, equal ambulacra, which form a regular rectangular cross, and extend along the 4 edges of the theca to the column. Theca 4-sided prismatic, and quadrate in transverse section. Three pectinirhombs (3 paired adanals and an unpaired baso-frontal)."

Genotype, *Pseudocrinites quadrifasciatus* Pearce.

This definition does not point out any essential characters of the genus further than that it has 4 ambulacra. As other genera of this family have the same number, the genotype must furnish the detailed generic characters.

Jaekel's definition, translated, reads as follows: "Theca oval, with 4 ambulacra having numerous crowded brachioles. Anal area small, between plates 7, 8, 13, and 14; one basal and 2 upper pectinirhombs normally situated, with long angulated rhombs and numerous single pores."

His remarks are as follows: "The theca on account of the 4 ambulacra is 8-sided in transverse section; the free sides are slightly domed and in the middle are nearly twice as wide as the ambulacra. Plate 14 abuts but very little against the anal area. The 4 ambulacra are the same as those of the Apiocystids, namely R I, R II, R IV, R V. They are equally developed and without exception continue to the base of the column. The number of brachioles is about 40 to each ambulacrum. The anus and the pectinirhombs, built and situated as in *Pseudocrinites*, are equally divided on the thecal sides between the ambulacra, so that the anus lies between R IV and R V, the basal rhomb between R I and R II, and the upper rhombs, one in each of the other two areas." For reasons mentioned in discussing *Trimerocystis*, the present writer regards the anus as between R I and R V.

The description and figures show clearly that *Staurocystis* is very closely related to *Pseudocrinites*, the plate structure being precisely the same in both; this is also true of the structural detail in the ambulacra. The former genus differs from the latter only in being 8-sided (essentially 4-sided) and in having 4 full-length ambulacra, *Pseudocrinites* being 2-sided and having but 2 ambulacra. Though *Trimerocystis*, also, is closely related, it differs from the other two, not only in being 6-sided (essentially 3-sided) and in having 3 ambulacra, but also in the arrangement of the thecal plates. These 3 genera agree in this, that the anal area consists of 2 circles of pieces and is placed between plates 7, 8, 13, and 14. *Pseudocrinites* and *Staurocystis* further agree in having the plates of the theca arranged alike, but in *Trimerocystis* they are disposed differently. This difference may best be expressed in tabular form, thus:

	Basal Circle	Circle 2	Circle 3	Circle 4
Pseudocrinites	4-1-2-3	5-6-7-8-9	10-11-12-14	16-17-18-13-19-15
Staurocystis	4-1-2-3	5-6-7-8-9	10-11-12-14	16-17-18-13-19-15
Trimerocystis	4-1-2-3	10-5-6-7-8-9	16-11-12-14	17-18-13-19-15

Forbes's figure 7 shows the anal area surrounded by plates 7, 8, 13, 19, and 14, but in his description he adds that "there is not sufficient material to make out the arrangement of the plates completely" (p. 499). Jaekel's diagram of this region, however, shows that plate 19 of Forbes is a part of plate 13, and that the arrangement of the thecal plates around the anal area is as stated above, i. e., 7, 8, 13, and 14.

In the *Treatise on Zoology*, Bather makes *Staurocystis* a synonym of *Lepocrinites* (*Lepadocrinus*), without, as the writer believes, sufficient reason. In the latter genus the ambulacra are more depressed and excavated into the thecal plates, are only half the length of the theca, and have relatively fewer brachioles. In *Pseudocrinites, Staurocystis,* and *Trimerocystis* the ambulacra are very conspicuous, highly arched, as long as the theca (with one exception), and have numerous brachioles. Added to these differences, the anal area in *Lepocrinites* is bounded only by plates 7, 8, and 13, yet in the other two genera these and plate 14 delimit this area. In *Lepocrinites,* furthermore, plates 7 and 8 are shorter than in the other genera, allowing plate 14 to enter the third circle, while in the others this plate is a member of the fourth circle.

Of *Staurocystis* but a single species is known, *S. quadrifasciatus* (Pearce). This occurs in the Wenlock limestone and Lower Ludlow of England.

Subfamily CALLOCYSTINÆ Jaekel

Callocystidæ in which the ambulacra bifurcate. Brachioles widely separated. Thecal plates variously arranged, owing to the plates of the higher rings shoving into the lower ones.

Callocystites Hall

Callocystites HALL, Nat. Hist. New York, Pal., II, 1852, pp. 238, 248.—HALL, ibidem, III, 1859, p. 151.—JAEKEL, Stammesgeschichte der Pelmatozoen, I, Thecoidea und Cystoidea, 1899, p. 289.—GRABAU, Bull. N. Y. State Mus., IX, 1901, p. 151.—GRABAU, Bull. Buffalo Soc. Nat. Sci., VII, 1901, p. 151.

Callocystis BATHER, Treatise on Zoology, III, Echinoderma, London, 1900, p. 62, text-fig. 31.

Anthocystis HAECKEL, Amphorideen und Cystoideen, Festschrift Carl Gegenbaur, Leipzig, 1896, p. 132, pl. 3, figs. 23, 24.

Emended definition.—Callocystinæ with the theca olive-shaped, the oral end being more attenuated and bluntly pointed, while the base is flat or truncated. Theca with 25 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, (11), 6, 12, 8, 14, 9, 10.

Third row has plates 16, (11), 17, 18, 13, 19, 15.

Fourth row has deltoids 20, 21, 22, 23 double, and 24. Hydropore and madreporite on the 2 parts of plate 23. The former is closed by a pyramid. (See text-figure 35.)

Anal area bounded by thecal plates 7, 8, and 13. Anal pyramid composed of 5 or 6 plates and surrounded by a ring of many minute pieces.

One basal and 2 upper generally discrete and rarely closely adjoining pectinirhombs, each discrete-rhomb being generally completely bounded by a highly elevated thickened margin.

Ambulacra wide and prominent, consisting of 5 simple ones or one or all of the rays may divide once, so that there may be from 5 to 10 ambulacra near the base of the theca. Brachioles widely separated, slender, and very long.

Genotype, *C. jewettii* Hall.

Jaekel gives 24 plates in his diagram of *Callocystites,* but it is certain that 25 are present. Bather, basing his diagram on Hall's work, also gives 25. The difference lies in the fact that plates 24 and half of 23, which are separate in the present specimens, are united by Jaekel.

The irregular variation in the branching of the ambulacra led the latter author to state that it " gives one the impression of a degeneration process." To the present writer it appears just the opposite, for if *Callocystites* is descended from a form having throughout life 5 simple rays, then the bifurcation of the rays beginning in *Callocystites* and developing to an extreme in *Sphærocystites* (apparently a descendant of the former) shows the course of development to be a progressive one. The degree of arm bifurcation in *Callocystites* is evidently not of specific value, and only occasionally is the primitive character of 5 simple rays maintained throughout growth in *C. jewettii.* It is to the latter type, illustrated by Hall in 1852, that Haeckel restricted the present genus, the specimens with bifurcated ambulacra being placed by him in a distinct genus under the name *Anthocystis.* In the opinion of the writer, Haeckel's generic distinction has not even the justification of a variety.

Callocystites is an American genus, of which only two species, C *jewettii* and *C. canadensis,* are known.

CALLOCYSTITES JEWETTII Hall

(PLATE XXXIV, FIGURES 1, 2)

Callocystites jewettii HALL, Nat. Hist. New York, Pal., II, 1852, p. 239, pl. 50, figs. 1–18.—JAEKEL, Stammesgeschichte der Pelmatozoen, I, Thecoidea und Cystoidea, 1899, p. 290, text-fig. 64 on p. 291, pl. 15, figs. 1–1c.—GRABAU, Bull. N. Y. State Mus., IX, 1901, p. 151, text-fig. 47.—GRABAU, Bull. Buffalo Soc. Nat. Sci., VII, 1901, p. 151, text-fig. 47.

Callocystis jewetti ZITTEL, Handbuch der Palæontologie, I, 1879, p. 410, text-fig. 290; p. 421, text-fig. 297.—HAECKEL, Amphorideen und Cystoideen, etc., 1896, p. 131, pl. 3, figs. 21, 22.—BATHER, Treatise on Zoology, III, Echinoderma, 1900, p. 62, text-fig. 31.

Anthocystis halliana HAECKEL, Amphorideen und Cystoideen, etc., 1896, p. 132, pl. 3, figs. 23, 24.

Length of largest theca seen nearly 35 mm., while the average length for a matured specimen is about 28 mm.

Ambulacra prominent and wide, extending to near the base of the theca. In some mature individuals the 5 primary ambulacra remain simple; in others all bifurcate once, making 10 ambulacra near the base of the theca; in others still, all branch except the ray to the left

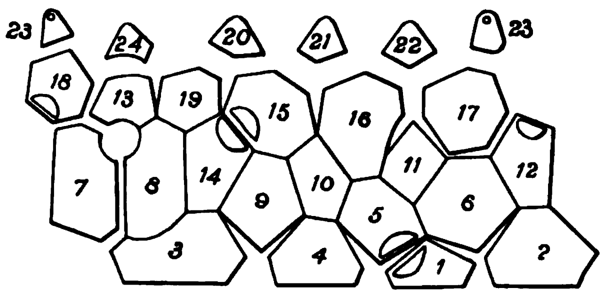


FIG. 35.—Analysis of *Callocystites jewettii* Hall, somewhat altered after Jaekel.

of the anus and the one to the left of the lower pectinirhomb. In *C. canadensis* further types of bifurcation occur, thus making it probable that any 1 or 2 of the rays may remain simple while the others divide. There is also no regularity in the period of branching, but as a rule it takes place before half the size of the theca is attained. On mature examples each simple or branched ambulacrum has on one of the outer sides about 11 brachioles; on the inner side of the branches about 6 or 7. Brachioles very long and slender, from 11 to 12 mm. in length, and composed of about 30 to 32 pieces in each range. Ambulacral grooves wide, not very deep, and covered by a series of very minute quadrangular ambulacralia of which there are in one range about 14 to 16 between each brachiole.

Basal pectinirhomb with about 17 pores, the upper ones varying between 12 and 15. Each rhomb usually is completely surrounded by a high, thickened wall. The walls are most prominent on plates 5, 12, and 14.

Madeporite ∞ -shaped and situated on the 2 parts of plate 23. Hydropore immediately beneath the madreporite, very small, and closed by a pyramid of 4 pieces.

Anal area not prominent, the pyramid composed of 5 or 6 pieces, and surrounded by a complete ring of 13 minute plates of variable size.

Column very stout, with thick joints near the theca, tapering rapidly in the upper half and more slowly beneath. Total length unknown but exceeding 6 cm. The upper half is composed of about 22 stout, highly carinated segments, the lower ones having the periphery more and more crenated. The lower half of the column is composed of high and slender, longitudinally striate segments.

The form with divided ambulacra, which Hall described and illustrated as the typical form of *C. jewettii*, was taken by Haeckel as the genotype for his genus *Anthocystis*, and named *A. halliana*. Jaekel considers the form with 5 unbranched ambulacra as possibly worthy of specific distinction, but with justice adds " in no case can one make it, as Haeckel has done, displace the type of *Callocystites*." In the present instance it is not regarded as worthy even of a varietal name.

Formation and locality.—When the Erie canal was dug, Colonel Jewett obtained quite a number of specimens in the Rochester shales about Lockport, New York, but the species is now a very rare one. In recent years Mr. J. Pettit found a number of excellent examples at Grimsby, Ontario, in the same geological horizon. These are now in the collection of Dr. B. E. Walker, Toronto, Canada, and were kindly lent to the writer for study.

Cat. number 35,136, U. S. N. M. Presented by Dr. Walker.

CALLOCYSTITES CANADENSIS (Billings)

(PLATE XXXIV, FIGURE 3)

Apiocystites canadensis BILLINGS, Geol. Surv. Canada, Cat. Sil. Foss. Anticosti, 1866, p. 90.

Callocystites tripectinatus RINGUEBERG, Bull. Buffalo Soc. Nat. Sci., v, 1886, p. 12, pl. 1, fig. 10.

This species is distinguished by the fact that the 2 halves of each pectinirhomb closely adjoin, there being no high, separating walls between them as in *C. jewettii*. When this feature is well preserved, as in a not fully mature specimen in Dr. Walker's collection and in the types of *C. tripectinatus* and *Apiocystites canadensis*, it is very striking. That the ambulacra in this species more often remain simple has no marked value, because some specimens have bifurcated arms, and in *C. jewettii* fully mature examples are also seen to have but 5 simple ambulacra. In a small but very fine, typical example of *C. canadensis*, all the ambulacra bifurcate once except the one to the right of the anus. In a larger but less typical specimen 4 of the ambulacra divide, but in this case the simple one is to the left of the anus.

Billings distinguishes his *Apiocystites canadensis* from *A. elegans* Hall by the 5 arms and the rhombs "not double, but single, i. e., the two triangles, of which each is composed, have their bases in contact, the elongated pores being continuous across the suture between the two plates on which each rhomb is situated." He also calls attention to the fact that one arm is shorter than the others. The holotype, now preserved in the collections of the Geological Survey of Canada, and kindly loaned to the writer by Professor Whiteaves, shows that the character of the rhombs and the number of arms are those of *Callocystites* and not of *Apiocystites*. Moreover, the other Canadian specimens studied by the writer come from the identical locality that furnished Billings's type. Both were collected by Mr. J. Pettit.

Ringueberg's *C. tripectinatus* is also a 5-armed individual, the rays having unequal length. Two of the rays are "slightly bifid at their lower extremity." His differential specific character is the "paired hydrospires" in contradistinction to the separated ones in *C. jewettii*. As he does not mention Billings's species *Apiocystites canadensis*, he was probably unaware of the identical type of pectinirhomb in that form.

Formation and locality.—Rochester shales at Grimsby, Ontario. Three specimens, collected by Mr. J. Pettit and now in Dr. Walker's collection. Another specimen was found near Lockport, New York, by Mr. Ringueberg.

Cat. number 35,135, U. S. N. M. Presented by Dr. Walker.

Cœlocystis Schuchert

Hemicosmites HALL (not von Buch), Twentieth Rep. N. Y. State Cab. Nat. Hist., rev. ed., 1868 [1870], p. 359.

Sphærocystites JAEKEL (not Hall), Stammesgeschichte der Pelmatozoen. Berlin, I, 1899, p. 289, fig. 63; also p. 307.

Cœlocystis SCHUCHERT, Amer. Geol., XXXII, 1903, p. 234.

Until recently, *Sphærocystites* seems to have been based on a single example—the holotype of *S. multifasciatus*. As this specimen did not permit Hall to make out the thecal structure, Jaekel gave the plate formula for the genus, basing it on *S. dolomiticus* Jaekel = *Hemicosmites subglobosus* Hall. In the present work the plate formula for *Sphærocystites* is based on the genotype *S. multifasciatus*, and this study has shown that Jaekel's type belongs to another and more primitive genus. For this reason the Niagaran form is here distinguished under the genus *Cœlocystis*, the name having reference to the deeply invaginated base of the theca.

Hemicosmites is a quite different form, as the plate formula is $4 + 6 + 9 + 9$, anal area 7, 8, and 13 (see Bather, *Treatise on Zoology*, III, *Echinoderma*, London, 1900, p. 68, fig. 3).

Definition.—Callocystinæ? having a depressed globular theca with a deeply invaginated base, and normally composed of 24 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 10, 5, 6, 12, 7, 8, 14, 9.

Third row has plates 16, 11, 17, 18, 13, 19, 15.

Fourth row has deltoids 20, 21, 22, 23 double, and 24.

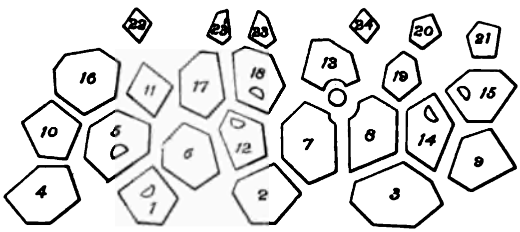


FIG. 36.—Analysis of *Cœlocystis subglobosus* (Hall).

Anal area bounded by plates 7, 8, and 13. The anal pyramid is apparently not surrounded by a circle of small plates as in *Sphærocystites*.

Pectinirhombs normally situated, small, discrete, and with but few dichopores.

As all the specimens are internal casts of the theca, the nature of the ambulacra, anal area, sculpture, and the column cannot be stated.

Genotype, *Hemicosmites subglobosus* Hall.

The foregoing definition and the diagrams here given show that *Cœlocystis* differs widely from *Sphærocystites* in that it has 6 additional plates and these have a quite different arrangement. The second row of the former genus has all the plates of the latter and in addition plates 10, 12, and 14; the third row has 7 plates and includes all the plates of the fourth row in *Sphærocystites*, while the deltoids of the fourth row in *Cœlocystis*, 5 in number, are not present (except 23 which is not double) in *Sphærocystites*.

A comparison of this diagram with that of *Sphærocystites* Jaekel (not Hall), in the work cited, shows that that author omitted plate 10 in the second row. Jaekel's diagram therefore has 24 plates, while that here represented has 25, counting the parts of plate 23 as separate pieces. The writer's material is excellent, and while considerable variation in the shape of the plates exists in different specimens, there seems to be little chance for error in the interpretation of their arrangement as given in text-figure 36.

Dr. B. E. Walker, of Toronto, Canada, has presented to the National Museum a very well-preserved specimen of *C. subglobosus*, which differs from all others in shape and in the number of plates. It is more globose, higher, and somewhat more drawn out posteriorly. The anal tube also protrudes more than is usual. This specimen, instead of having 25 plates, the normal number, has 29, as shown in the following diagram. An analysis based on normal specimens leads

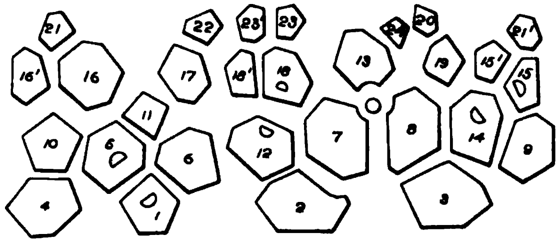


FIG. 37.—Analysis of an abnormal specimen of *Cœlocystis subglobosus* (Hall).

to the conclusion that plates 15, 16, 18, and 21 are divided, thus producing the 4 additional plates. It seems rather odd that division in these plates takes place so irregularly; 2 of the plates bear pectinirhombs, one being a simple thecal plate, and the other a deltoid.

The only species of this genus is *C. subglobosus* (Hall).

CŒLOCYSTIS SUBGLOBOSUS (Hall)

Hemicosmites subglobosus HALL, Twentieth Rep. N. Y. State Cab. Nat. Hist., rev. ed., 1868 [1870], p. 359, pl. 12, fig. 13.

Sphærocystites dolomiticus JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 289, fig. 63.

Cœlocystis subglobosus SCHUCHERT, Amer. Geol., XXXII, 1903, p. 235.

Rare in the Niagaran limestone about Chicago, Illinois. See text-figures 36 and 37 for the analysis of two specimens of this species.

Cat. numbers 35,061 and 35,155, U. S. N. M.

Sphærocystites Hall

Sphærocystites HALL, Amer. Jour. Sci. (2), XXV, 1858, p. 279.—HALL, Nat. Hist. N. Y., Pal., III, 1859, p. 130.—SCHUCHERT, Amer. Geol., XXXII, 1903, p. 232.

Sphærocystis HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 133.—BATHER, Treatise on Zoology, III, Echinoderma, London, 1900, p. 63.

Original definition.—" Body spheroidal, wider than high. Arms in two principal pairs, with numerous bifurcations. Brachial sulci obliquely lobed. Mouth longitudinal ? apical: anus [= madreporite] subapical: ovarian [= anus] opening upon the summit.

Basal plates four; those of the series above not determined. Base depressed. The species have the general aspect of *Callocystites* or *Lepadocrinus*. Column unknown."

Jaekel's[1] definition of *Sphærocystites* cannot be accepted, as it is not based on the genotype *S. multifasciatus*, but on *S. dolomiticus* Jaekel (= *Hemicosmites subglobosus* Hall) of the Niagaran dolomites of Chicago, Illinois. The latter species, having a greater number and a different arrangement of thecal plates, has been made the type of *Cælocystis*.

Emended definition.—Callocystinæ with the theca varying between depressed echinus-shape with a deeply excavated base to elongate-globular form with almost no excavated base. Theca with 18 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6 (sometimes part of 12), 7, 8, 9.

Third row has plates 10, 11, 12, (7, 8), 14.

Fourth row has plates 16 (17 absent), 18, 13 (19 absent), 15.

Fifth row has deltoid 23, with madreporite and hydropore.

Anal area not prominent, bounded by thecal plates 7, 8, and 13. It is composed of 2 circles of plates, an outer of from 10 to 14 pieces of variable size, and the pyramid with 6 or 8 pieces.

One basal and 2 upper discrete-pectinirhombs, with numerous dichopores.

Ambulacra not much elevated above, and but slightly excavated into, the theca, beginning with 4 rays and bifurcating variously in different specimens of the same species, until 27 branchlets result. Brachioles widely separated, slender, short and club-shaped.

Madreporite large, with a small hydropore immediately below. The latter is closed by a pyramid of 4 or 5 pieces.

Column stout, tapering rapidly for a short distance and then hardly at all throughout the remainder of its length. Total length about 95 mm. Base of attachment terminating in a few roots.

Genotype, *S. multifasciatus* Hall.

To the foregoing description should be added the fact that in *S. multifasciatus* plate 12 enters the second row and rests partly on plate 6 and directly on plate 2 of the basal row. This is due to the depressed form of the theca. In *S. globularis* the case is different, as plate 12 rests directly on plate 6.

The feature distinguishing *Sphærocystites* from all the associated genera is that the theca has but 18 plates. Plates 17 and 19 of other

---

[1] Stammesgeschichte, etc., 1, 1899, pp. 288–9.

genera are here absent. Another marked feature is that the 4 primary ambulacra are abundantly branched.

SPHÆROCYSTITES MULTIFASCIATUS Hall

(PLATE XXXVIII, FIGURES 1, 2; PLATE XXXIX, FIGURES 1-4)

Sphærocystites multifasciatus HALL, Nat. Hist. N. Y., Pal., III, 1859, p. 130, pl. 7A, figs. 1-4.—JAEKEL, Stammesgeschichte der Pelmatozoen, Berlin, I, 1899, p. 289.—SCHUCHERT, Amer. Geol., XXXII, 1903, p. 233.
Sphærocystis multifasciatus HAECKEL, Die Amphorideen und Cystoideen, Beitr. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 133.

Length of one of the largest theca 19 mm.; transverse diameter in both directions 24 mm. Another large theca has a length of 19 mm.; diameter in the direction of the two upper pectinirhombs 20 mm., and in the opposite direction through the anus 22 mm. A greatly depressed specimen has a length of 13 mm., and a diameter of 20 mm. A young theca has a length and diameter of 9 mm. Base of theca more or less excavated, greatest in the depressed specimens. Plate 12 rests on basal plate 2. For general form, shape of individual plates and their ornamentation, see the plate-figures and diagram.

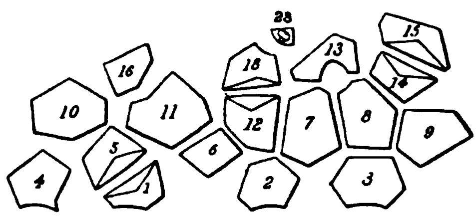


FIG. 38.—Analysis of *Sphærocystites multifasciatus* Hall.

Ambulacra 4, branching rapidly and with no apparent regularity, the branches varying between 14 in the youngest to 27 in the largest

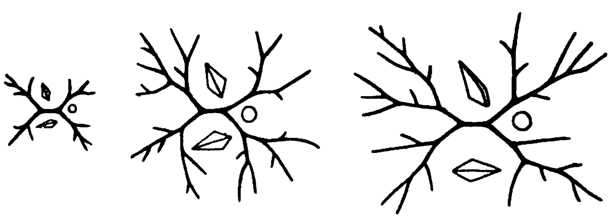


FIG. 39.—Diagrams showing the manner and number of ambulacral branches in a young, adult, and old specimen of *S. multifasciatus* Hall.

theca. These spread between and around the anus and pectinirhombs until the greater portion of thecal surface is occupied by them, obscuring the suture lines between the thecal plates. Brachioles widely separated, about 3 in 5 mm.; club-shaped, tapering to a point, and about 3 mm. long. Ambulacrals large, to each of which there are about 5 ambulacralia.

Dichopores in sharply delimited, low, angulated, discrete pits; in other words, the grooves of the 2 parts of the pectinirhombs do not meet each other at the suture lines of the plates of which they are a part, but are restricted to the prominent pits. From 40 to 45 grooves in each pit.

Anal pyramid depressed, composed of 6 pieces and surrounded by a ring of 3 large aboral and 7 small oral pieces.

Hydropore minute, closed by a pyramid of 4 pieces, and situated immediately in front of the large madreporite occupying the greater portion of plate 18.

Column slender, with about 16 stout and equally large segments beneath the theca, followed by others of unequal size of which the larger segments are widely separated.

Formation and locality.—Hall states that his specimen came from "the limestones of the Lower Helderberg group, Cumberland, Maryland." This usage of "Lower Helderberg" is the old one, now obsolete, including the Tentaculite limestone or Manlius formation. About Cumberland, this species is very rare, probably not more than four specimens are known, but in the quarries near Keyser, West Virginia, more than 4,000 specimens have been picked up during the last three years. Here they range through the middle layers for about 37 feet, associated with the other common cystids, *S. globularis, Pseudocrinites gordoni, Jaekelocystis hartleyi,* and several species of crinoids.

Cat. numbers 35,052, 35,058, U. S. N. M.

SPHÆROCYSTITES BLOOMFIELDENSIS n. sp.

Length of theca 14 mm.; diameter 15 to 16 mm. Depressed globular, with the base not excavated.

Thecal plates arranged as in *S. globularis;* otherwise this species is closely related to *S. multifasciatus.*

Of this form, the two known thecæ were greatly exfoliated in breaking them from the shaly limestone, so that most of the specific characters are not determinable. However, the shape allies the species with *S. multifasciatus* from which it differs in having no excavated base and in plate 12 not resting on plate 2 of the basal row, but upon plate 6 of the second row as in *S. globularis.* It probably differs further, not only in the smaller and more spheroidal theca, but also in having the ambulacra less branched. From *S. globularis* it is distinguished by the more depressed theca and more strongly sculptured plates. In *S. bloomfieldensis,* plate 18 is much larger than in the other two species, and the madreporite is therefore comparatively more conspicuous.

Formation and locality.—The writer found this species at the base of the Manlius, at Clark's Mill, near New Bloomfield, Pennsylvania. It appears to have been a common form, as the separated thecal plates occur abundantly. It is associated with *Pseudocrinites claypolei.*

Cat. number 35,059, U. S. N. M.

SPHÆROCYSTITES GLOBULARIS Schuchert

(PLATE XXXVIII, FIGURES 3–5; PLATE XXXIX, FIGURES 5, 6)

Sphærocystites globularis SCHUCHERT, Amer. Geol., XXXII, 1903, p. 233.

Length of a large and regular theca 22 mm.; transverse diameter 20–21 mm. Base not excavated. Plate 12 resting on plate 6 of the second circle.

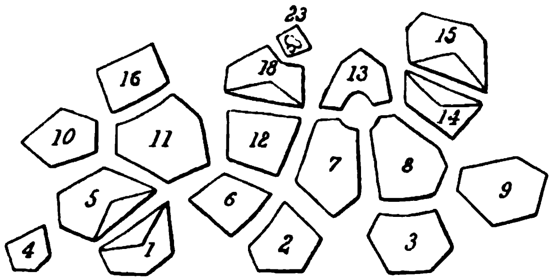


FIG. 40.—Analysis of *Sphærocystites globularis* Schuchert.

Ambulacra branching with no apparent regularity, the branches in adults varying between 9 and 14. Ambulacralia about 7 to each ambulacral.

Anal pyramid depressed, composed of 8 pieces, and surrounded by a ring of 4 large and 10 small plates.

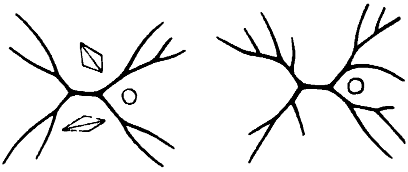


FIG. 41.—Diagrams showing the number of ambulacral branches in two specimens of *S. globularis* Schuchert.

Hydropore minute, closed by a pyramid of 5 pieces, and situated immediately in front of the elongate dumb-bell-shaped madreporite on plate 21.

Column tapering rapidly for a very short distance and then hardly at all throughout the remainder of its length. Total length about 95 mm., with the root end about 7 mm. high. First 11 segments beneath the theca thinnest, with angulated peripheries, followed by about 65 segments of nearly equal size and rounded edges.

This species is readily distinguished from the associated *S. multifasciatus* by the globular form of the theca, the non-excavated base, the smaller number of ambulacral branches, thus causing the surface to appear smoother; finally, by the higher position of plate 12, which does not attain the basal row as in that species.

Formation and locality.—Not rare in the cystid beds of the Manlius in the quarries near Keyser, West Virginia.

A specimen with the entire column was found by Mr. Gordon in the bryozoa beds of the Manlius, at Devil's Backbone, near Cumberland, Maryland.

Cat. numbers 35,053, 35,077, U. S. N. M.

S. GLOBULARIS OVALIS n. var.

(PLATE XXXVIII, FIGURE 6)

Associated with *S. globularis* are specimens that attract attention on account of their more elongate and regularly ovate thecæ. These specimens never attain the size of that species, however, and they commonly retain a portion of the column, a feature much more rare than in the variety *ovalis*. In addition to the smaller size, and the rounded-ovate outline of the theca, the variety is further distinguishable in always having the 4 ambulacra less bifurcate. The number of branchlets varies between 5 and 10, the average being 6 or 7. In 13 specimens, the ambulacra divided as follows: 1 with 5 branchlets, 4 with 6, 4 with 7, 2 with 8, 1 with 9, and 1 with 10. In *S. globularis* the average number of branchlets is between 10 and 12.

Cat. number 35,054, U. S. N. M.

Class *CRINOIDEA*

? Order MONOCYCLICA CAMERATA

Family CAMAROCRINIDÆ Barrande (emend.)

Camarocrinus Hall

Camarocrinus HALL, Twenty-eighth Rep. N. Y. State Mus. Nat. Hist., Mus. ed., 1879, pp. 205–6; extract, 4°, with additions, 1880, pp. 3–5. —ZITTEL, Grundzüge der Palæontologie, 1895, p. 154.—ZITTEL and EASTMAN, Text-book of Palæontology, 1896, p. 183.—HAECKEL, Die Amphorideen und Cystoideen, Leipzig, 1896, pp. 168–169.—BARRANDE and WAAGEN, Syst. Sil. du Centre de la Bohême, VII, pt. I, 1897, p. I.—BATHER, Treatise on Zoology, III, Echinoderma, 1900, pp. 77, 136, 161.

This imperfectly understood echinoderm has been variously regarded as the float or the inflated root end of a crinoid or the theca of a cystid. These bodies have recently been found in considerable numbers in such widely separated localities as Maryland, Tennessee, and Indian Territory. The material from the last region is best preserved and permits of the determination of every detail.

The writer has been enabled to work out much that is new regarding the minute structure of these objects as well as their occurrence in the strata. Before proceeding to their description, however, it is deemed advisable to give a rather full account of what others have said about them, followed by a statement as to their occurrence in the various geological formations.

History of the Genus

The first American to find *Camarocrinus* appears to have been John Gebhard, Jr., of Schoharie, New York. Dr. John M. Clarke, in a letter to the writer dated Albany, New York, January 7, 1904, furnished the following interesting statement: "Do you remember John Gebhard, Jr.—Squire John as his friends liked to call him—or had he passed on before your day in Albany? He died in 1887 at a very advanced age. Your quandary over the nature of *Camarocrinus* reminds me of his ready interpretation of it. The Squire was the most assiduous collector of fossils of his day in this country and I have no doubt was the first to discover this strange fossil. He had extensive collections and a detailed knowledge of the rocks in Schoharie county before the New York Survey came into being. When Lyell came to America [1841–42], Hall took him over to Schoharie to see the region and the Gebhard collections. In them were fine slabs of *Tentaculites gyracanthus* from the Tentaculite limestone and Lyell said to Gebhard (the Squire himself told me this) 'Here you have the spines of sea urchins, see if you cannot find the echinus itself.' This Gebhard set himself to do and accomplished his purpose, finding *Camarocrinus*. To him these bodies were always sea urchins whose spines were *Tentaculites*."

Hall describes *Camarocrinus* as follows: '

"Body large, externally lobed, chambered within, varying from transversely or longitudinally oblate-spheroidal to subspherical, and frequently assuming an unsymmetrical form from the unequal development of the lobes corresponding to the internal chambers. The cavity of the body or dome is divided into two or more large compartments, with usually several smaller accessory chambers, by vertical and horizontal partitions which are extensions of the substance of the inner walls of the dome.

"The basal portion occupies a subcircular area, which is placed in a central position with regard to the disposition of the lobes of the body, and is surrounded by an elevated projection or extension of the walls. In structure this area is composed of spreading, radiciform, bifurcating rays, connected by irregular polygonal plates. The basal rays are composed of joints similar to those of an ordinary crinoidal column, and vary in number from five to twelve or more, and are arranged symmetrically with respect to two axes at right angles; they bifurcate at the third or fourth segment from their origin, and enclose ambulacral openings which penetrate into the interior cavities of the body.

"The external wall of the dome is composed of two distinct layers, of which the infolding and extension of the inner one forms the partitions dividing the chambers. No traces of free arms have been observed. Column cylindrical, smooth near the body; the segments regular. The interior canal is five lobed, and is divided and continued through the basal rays and their ramifications; not opening into any interior cavity of the body, so far as observed."

Hall's remarks on this fossil are as follows:

"This remarkable crinoidal body is so totally unlike any previously described form, within my knowledge, that its true characters and relations are not at once evident. There is no doubt as to its crinoidal nature, but there is no apparent analogy of its parts with ordinary crinoids. Some of its characters would indicate that it is a curiously modified and enlarged summit or dome; that the visceral cavity is a small internal chamber immediately over the column-attachment; and that the lobes are an abnormal development of the interbrachial or interradial spaces. But the more probable theory in regard to this fossil, points to a functional similarity with a crinoidal root, as in *Ancyrocrinus* from the Upper Helderberg and Hamilton groups, in which there is a bulbous growth at one extremity of the column, supposed to act as a float or anchor to the body and arms. Viewing it in this respect, it may be regarded as a large chambered bulb, with an attached column, on the distal extremity of which was a calyx, having characters unknown at the present time. In this aspect, it must have been a free floating organism, similar in its habits to the recent *Medusæ* and *Comatulæ*. The lack of definition and symmetry which these crinoidal bodies assume would be an argument in support of this view, and find explanation in their consequent secondary functional importance, and separation from the governing center or centers."

Barrande in Waagen states the following:

"The family of Lobolithes is known only by the publication of Prof. J. Hall under the name of *Camarocrinus*.

"Indeed for more than forty years we have shown visiting savants these remarkable specimens in our collection, which, however, we do not suppose have made a deep impression on their minds. We announced these under the new name, Lobolithes, but have not called attention to them by a proper publication. The time has been lacking.

"We now show the very diverse forms of this family on 13 plates numbered 67 to 79 [not yet published].

"At this time we will not make comparisons between Lobolithes and related families as the Cystidea and Crinoidea. A cursory examination of the 13 plates by an intelligent student will at once show him that our new echinoderms are distinguished by the absence of all regularity in their structure."

Zittel's description, as translated by Eastman, is as follows:

"Family 3. Camarocystidae. Barrande.

"Calyx globose or discoid, composed of numerous polygonal plates, and sometimes fixed by the ventral surface [this seems to refer only to *Lichenocrinus* as will be seen later]. Interior of calyx divided into four to six compartments by partitions corresponding in position to lobes on the exterior. Stem long and slender. Silurian.

"This family embraces two genera whose systematic position is still doubtful. The larger, *Camarocrinus,* Hall (=*Lobolithes,* Barrande), occurs in the middle and upper members of the Silurian in North America and Bohemia, and attains considerable size. The smaller, *Lichenocrinus,* Hall, is more or less crateriform, has a very long, tapering stem, and is invariably attached by its flattened ventral surface. It is found in the Ordovician (Hudson River Group) of North America."

It should be stated that *Lichenocrinus* has no direct relationship with *Camarocrinus,* as it is a sessile body with a long column; the base is composed of an upper series of small porous plates beneath which is a very thin chamber with the basal layer finely striate radially. There are no camaræ like those in *Camarocrinus.* The latter, on the other hand, is a free body, and is never sessile nor cemented to foreign objects as is *Lichenocrinus.*

Haeckel's remarks, translated, are as follows:

"In the Silurian System of Bohemia Barrande discovered quite 50 years ago the remains of large Echinoderma to which, in the 'Programme Generale' of his large work on Cystidea, he has applied the name *Lobolithus* (Syst. Sil. du Centre de la Bohême, VII, 1887,

p. 1). He regarded them as the type of a new and peculiar class of Echinoderma, differing in their composition from all others 'by the absence of all regularity.' These remarkable, irregularly rounded, bladder-like bodies, attaining a diameter of several (up to 18) centimeters, have been figured by Barrande on 13 plates, not yet published, of his work (provisionally designated as plates 67 to 79).

"Similar bodies were found later in the Silurian of North America by James Hall; at first (1872) he described them as Cystids [this is an error, as the citation given seems to have reference to a paper on *Cyclocystoides*]. Later (1879) he declared them to be modified, bladder-like, swelled roots of true crinoids, an air-filled swimming apparatus. This view is also held, as I have learned through correspondence, by the Vienna geologists, Professor Waagen and Dr. Jahn, who have carefully studied the Bohemian Lobolithes and who will publish the plates of Barrande with descriptions. . . .

"In a letter from Zittel I learn that he also is now of the same opinion as Hall, Waagen, and Jahn.

"The 13 lithographed plates of Barrande, which I have seen, have figures of many Lobolithes of natural size: they are globular, or irregularly rounded cysts or bulbs, with thick walls consisting of small polygonal plates. Most of the capsules have the size of a child's head; the largest attain a diameter of 0.2 meter and over. The plates, with their peculiar structure, when magnified, show that we are here dealing with Echinoderma. A first inspection of many figures might lead one to regard them as irregular mailed-capsules of simple Amphorids, similar to *Aristocystis, Deutocystis,* etc. Against this determination, however, there are two decided facts: I. The mailed-capsules show no openings [they have many large openings] but are completely closed. On one end they rested directly on the sea bottom (they are as the description states 'cemented by the flattened crown') [this is never the case in either *Camarocrinus* or *Lobolithus*]; on the opposite side there arises a slender column, which may attain a length of several meters. II. The column is five-sided, prismatic, segmented, and has wholly the structure of an ordinary crinoid column; the single segments show on the articulating surfaces a central opening (stone canal) and a regular five-rayed stellate figure. This characteristic structure is entirely restricted to the class Crinoidea, and occurs in no other Echinoderma; it is absent in the true Cystoidea and in the Amphoridea as well. This fact indicates that in the Crinoidea alone the 'chambered organ', or the five-chambered tube, extends from the base of the cup through the hollow segmented column. In the Cystoidea, on the other hand, the pentaradial structure is restricted to the theca.

"A personal examination of well-preserved Lobolithes has enabled me to convince myself that the view of Dr. Jahn is correct; they are without doubt bladder-like swellings of large Crinoid columns. However, I do not regard them as 'swimming apparatus' but rather as brood-pouches or (probably) pathologic cysts caused by parasites. Similar structures have been described by Ludwig von Graff both in fossil and living crinoids, and he has furnished the proof that they are produced by the same parasites, Annelida of the genus *Myzostoma;* he compares them correctly with 'plant-galls' (Ueber einige Deformitäten an fossilen Crinoideen, Palæontolographica, Bd. 31, 1885)."

Bather, in the work cited, states:

"*Camarocrinus,* Hall (syn. *Lobolithus,* Barr.), root of a Crinoid (*Scyphocrinus,* apud Jaekel)" (p. 77).

"Another curious modification [of crinoids], perhaps connected with a free-floating existence, was presented by the root of *Scyphocrinus.* This swelled out into a hollow, chambered, balloon-like body, referred by Barrande to an independent class of Echinoderms under the name *Lobolithus,* and described by Hall as a float, which he called *Camarocrinus*" (p. 135).

Under *Scyphocrinus* Bather states "root a large hollow spheroid strengthened by internal septa, regarded as a float (= *Camarocrinus*) by Hall, as a cystid (= *Lobolithus*) by Barrande" (p. 161).

After having collected a large number of *Camarocrinus* in Maryland during 1901, the writer concluded they must be cystids, using this term in the old sense. This idea was communicated to Mr. Frank Springer, and on December 31, 1901, he wrote as follows:

"These strange organisms are a complete puzzle to me, and I never could frame any theory of their nature which was not at once swamped under a multitude of objections.

"I still am inclined to think Hall's explanation the most probable, although from anything we know about crinoid structures it is difficult to conceive what such a chambered mass had to do with the roots. I cannot see how they can be cystids."

Dr. Jaroslav F. Jahn, Brünn, Austria, who is preparing a monograph of Barrande's material of *Lobolithus,* writes me as follows:

"You probably know through Professor Jaekel that I regard *Lobolithus* as bladder-like root structures of crinoids that probably have served as brood-pouches [or brood-receptacles, Brutsbehälter]. I don't think these bodies are swimming apparatus, because they are too heavy."

Later the writer sent Professor Jahn a collection of *Camarocrinus*, to illustrate his own views as to the nature of these bodies. In reply was received the following comment, under date of April 3, 1904:

"After having seen the *Camarocrinus* you sent me I am convinced that *Camarocrinus* and *Lobolithus* are identical. I have never regarded *Lobolithus* as brood-sacks but as brood-receptacles [his word is Brutsbehälter]. Because I do not regard *Lobolithus* as the entire animal but as isolated skeletal parts, I prefer the older name *Lobolithus* [older only as a *nomen nudum*]. This name in itself says nothing (as *Entrochus* for columns) while *Camarocrinus* indicates an independent genus of crinoids. By *Lobolithus*, therefore, I understand, in part, crinoid-roots modified into brood-receptacles. In other words, of morphological significance I regard the Loboliths as bladder-like transformed crinoid roots, whose physiological significance is not yet entirely clear as brood-receptacles, etc. That all of these bodies do not belong to *Scyphocrinus* has always been clear to me because Loboliths also occur in Bohemia in beds where no *Scyphocrinus* has ever been found. That certain Loboliths belong to *Scyphocrinus* is proven by the circumstance that I have observed at Kuchelbad [the writer also saw one at this locality to which reference will be made later] on the exposed surfaces of the strata Loboliths connected by long columns to *Scyphocrinus* calices. The drawing of this I will publish. Of *Scyphocrinus* we know but few with attached columns; most of the columns occur isolated and these may belong to other genera. The dimensions and the form of the central canal in *Scyphocrinus* are variable. I know of Loboliths that have as thick a column as *Scyphocrinus*. Which forms of Loboliths belong to *Scyphocrinus* and which to other genera cannot of course be determined. It is remarkable that *Lobolithus* is found only in e 1β and in e 2. In f 2 they have not yet been found and it is therefore all the more remarkable that in America *Camarocrinus* (= *Lobolithus*) is restricted to beds the equivalent to our étage F, and also that *Scyphocrinus* has not yet been found in America."

The idea that *Camarocrinus* physiologically represents brood-sacks or brood-receptacles, first suggested by Haeckel and now provisionally accepted by Jahn, is so foreign to any known crinoid structure, that it was submitted to Springer for further comment. Under date of April 18, 1904, he writes:

"These strange bodies have always been, and still are, a complete puzzle to me. I can readily endorse the part of Jahn's statement that they are 'bladder-like swellings of the roots of crinoids,' but I have to halt at the 'brood-receptacles,' for I know nothing of them in any Pelmatozoa. The breeding organs of the living crinoids are located in the pinnules. The fertilized eggs are scattered in the water singly or in bunches and become attached by means of a glutinous substance to other objects. There is nothing in their known habits to suggest any gathering of the progeny of an individual about it like a brood. The Comatulæ, when developed, swim in schools, and the crinoids generally are no doubt gregarious.

"I cannot see that they are calyxes, of Cystids or anything else. Hall's idea that they may have served as an anchor or float, remotely comparable to the anchor of *Ancyrocrinus*, seems to me about the most plausible of anything yet suggested. I do not believe they were expansible, but think they must have been firm growths. The condition of preservation indicates that, for if pliant or expansible we should find them generally collapsed and flattened in the fossil state."

Another collection was sent to Professor Jaekel, Berlin, who, under date of March 10, 1904, comments as follows:

"Hearty thanks for your sending of *Camarocrinus* which of course are very much like those of Bohemia. As both belong to very different horizons I am all the more convinced that they are bladder-like developments of roots. These at all times had an indifferent character and under similar local conditions did develop similar forms at very diverse places in the Pelmatozoa."

Mode of Occurrence of Camarocrinus in the Rocks

West Virginia.—In the ballast quarries of the B. & O. R. R. near Keyser, West Virginia, *Camarocrinus* occurs in considerable numbers in the shaly partings between thick beds of a compact, dark-blue limestone, near the middle of the Manlius formation. As the quarrymen do not care for dimension stone, and as the strata stand nearly vertically, they drill holes as deep as 15 feet for dynamite charges and throw down with one blast hundreds of tons of rock. On one of these occasions, in the summer of 1901, the writer examined the upper side of a slab of limestone many square yards in extent, and saw on it, partially buried in the rock, at least 10 *Camarocrinus*, nearly all of which presented their upper or unstalked end; apparently not more than two of the ten specimens had the stalked end uppermost. On this great slab there was not a trace of other fossils, not even a segment of the column of an echinoderm. This fact led at once to the hypothesis that *Camarocrinus* had no long stalk, and also that it did not represent the root end of a crinoid. Four good collectors, as well as the quarry foreman, have watched this layer at sundry times during the last three years, and, while hundreds of

Camarocrinus have been gathered, no crinoids have been seen. The only other Echinoderma from these layers is a single specimen of *Trimerocystis peculiaris.*

Indian Territory and Oklahoma.—In 1901 Dr. E. O. Ulrich, while engaged on stratigraphic work in Indian Territory, also found *Camarocrinus* very plentifully. Letters to the writer dated September 8 and October 1, 1901, state:

"Of Helderbergian fossils perhaps my principal find is the discovery of a well-marked *Camarocrinus* bed, which I have traced over 50 miles [later he extended its range to 100 miles] and from which I have procured something like 400 select specimens—ranging in diameter from 1 to 5 or 6 inches. Without much trouble I might have collected a thousand. To show their abundance will say that I took about one of every ten seen.

"You ask about other crinoids associated with *Camarocrinus.* Only at two localities did I find anything of that kind in that bed. I am fully satisfied that what you call the 'bulb' is all there is, or ever was, to the fossil. There is absolutely not a sign of other crinoidal matter in most of the deposit containing *Camarocrinus.*"

To show the mode of occurrence and abundance, Mr. Ulrich procured a small slab measuring 25 × 13 cm. On the upper surface (see plate XLIII) it shows 5 specimens having diameters ranging between 3.5 and 10 cm. Not one of these has the stalk end turned upward, there are no stalk fragments in the matrix, and but few scattered plates of crinoid brachia. The latter may belong to *Edriocrinus,* as the basal portion of this crinoid is often found attached to *Camarocrinus ulrichi.* It is noteworthy, also, that this slab was collected at one of the two localities in which a few fragments of other Crinoidea were found in association with *Camarocrinus.*

Tennessee.—In southwestern Tennessee, in the valley of Tennessee river, Mr. Foerste found many specimens of *Camarocrinus saffordi* ranging through the lower 50 feet of the Linden formation. This geologic horizon is about the equivalent of the New Scotland of the New York Helderbergian. The species was found at several places, and the present writer found three specimens considerably farther northwest, in Benton county. Nowhere in this region, in the strata here referred to, are the thecæ of crinoids found, nor does Mr. Foerste mention finding crinoidal limestone or fragments of crinoid columns. The writer saw only crushed *Camarocrinus* in Benton county and no crinoidal fragments.

It should be noted that the southwestern occurrences of *Camarocrinus* (i. e., in Tennessee and Indian Territory), are in the New

Scotland zone of the Helderbergian, which is regarded by most paleontologists as near the base of the Lower Devonic. The other American occurrences are in the lower portion of the Manlius, the last stage of the Siluric.

Bohemia.—In the summer of 1903 the writer visited one of the localities in Bohemia furnishing *Camarocrinus* and *Scyphocrinus* in association, on the same bed of limestone. This locality is an abandoned quarry in the Schwartze Schlucht near Kuchelbad, a few miles up the Moldau river from Prague. It is the locality referred to by Dr. Jahn in his letter quoted above. Here is exposed a very extensive, nearly vertical wall of black limestone, with a thin shale surface. This limestone forms a horizon near the top of E eβ of Barrande's section and is regarded as the transitional zone to E e2. The horizon is to be correlated with the American Rochester shale. On the wall are seen many flattened globular bodies, some of which are *Lobolithus,* or rather *Camarocrinus,* and poorly preserved thecæ of *Scyphocrinus.* One of the latter preserved a long column probably not less than 3 feet in length, extending toward and terminating upon a *Camarocrinus.* The evidence then appeared to the writer so convincing that he told Dr. Perner, who had guided him to the locality, that there seemed to be no longer any doubt of *Scyphocrinus* and *Camarocrinus* belonging to one species. The proof, however, was decidedly at variance with the American occurrence of *Camarocrinus,* as crinoids are never found associated with it. Finally, the writer observed that the long column of *Scyphocrinus* lying across the *Camarocrinus* was at least twice as thick as any column of the latter he had seen. Since then he has determined that the central canal in the column of *Camarocrinus* is different in shape and very much smaller in size than in the associated *Scyphocrinus* columns. These differences are illustrated in the accompanying figure 42.

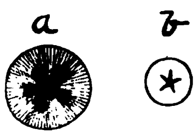


FIG. 42.—Transverse sections through the stalks, *a*, of *Scyphocrinus elegans* Zenker, near theca; *b*, a thick stalk of *Camarocrinus ulrichi*, near roots.

These figures of the central canal in the column of *Scyphocrinus* are from close to the theca, but what the shape and size of this canal are near the other extremity of the column can not now be stated. Granting, for the present, that the canal near the root end has the size and shape of that in *Camarocrinus,* the size of the column in the latter is still considerably smaller than the column of *Scyphocrinus* which the writer saw lying across the bulb in the abandoned quarry near Kuchelbad. It therefore does not appear that the two parts can belong to one animal.

Camarocrinus Hall (emend.)

(PLATES XL–XLIV)

Pyriform, spheroidal or depressed spheroidal chambered bodies, composed of a great number of small plates to one end of which are attached roots and a short stalk of the same nature as those of crinoids. There is no evidence of ambulacra, mouth, or anus. Immediately inside the base of the bulb is a large, more or less pentagonal medio-basal chamber, around which are usually arranged 5 or 6, and more rarely as many as 11 variously shaped chambers. The walls of the camaræ have their origin in bifurcations of the roots beneath the stalk. The walls of the chambers are double and are made up of small, irregularly shaped plates, the walls for the greater part closely adjoining and parallel, and united to one another by many short, stout, blunt processes. Along the periphery of the theca these walls bend over quickly and unite with one another in such a manner that from 5 to 11 interradial, large hollow lobes or water chambers are formed. Each lobe has a large opening in the base of the theca immediately inside the lateral basal extension or basal rim of the outer wall. The inner walls are surrounded by an outer integument of innumerable small plates devoid of regular arrangement. The origin of this outer wall is independent of the roots. Communicating pores, irregularly distributed, exist between the plates of both the outer and inner walls, except those of the base beneath the medio-basal chamber.

In very young specimens, nearly all of the outer integument has irregularly distributed functional pores between the plates, but in older examples a more or less thick, amorphous secondary coating occurs over about one-third of that end of the bulb to which the stalk is attached, closing all the pores of this region. Very often in old specimens of *C. ulrichi*, encrusting animals are found upon this secondary coating, as *Edriocrinus*, bryozoa, and brachiopoda (*Leptænisca*). By this condition of preservation it is natural to infer that the pores between the outer plates were functional (for the oxygenation of the blood?) and that no parasitic animals attached themselves to any part of the bulb until the secondary coating was deposited.

In many of the Indian Territory specimens the lower part of the bulb is prolonged into a high, thick-walled collar 10 to 15 mm. high, and in such there is always about the same length of stalk preserved.

The shape and size of the medio-basal chamber are very variable. In some it is large and regularly pentagonal in transverse section, gradually tapering upward between the walls of the surrounding camaræ. In others, one or more of the interior walls crowd upon this area, and this cavity then becomes very irregular in shape and much reduced in size. However, in all specimens there is more or less of a chamber just beneath the stalk and between the walls of the camaræ.

The camaræ occupy by far the larger part of the bulb and are very variable in shape, size, and number. The usual number is 5 or 6 (rarely 11), and additional chambers are introduced by bifurcation of the roots beneath the stalk. In *C. ulrichi* they often occur in pairs, and in some individuals there are 4 of these small chambers in pairs situated on opposite sides. Such specimens will have 8 or 9 chambers surrounding the medio-basal cavity. The greatest number observed is 11. Usually the number of camaræ is indicated on the outside of the theca by constrictions over the walls of the interior.

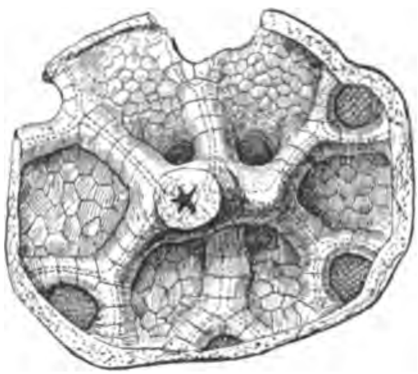


FIG. 43.—View of the base of *Camarocrinus ulrichi*; the interior canals of the roots are indicated by broken lines. × 2.

The base of the bulb inside of the more or less high collar is composed of 2 sets of plates—one series consisting of larger pieces, fairly regularly arranged, and restricted to the roots that radiate from the stalk; the other of irregularly shaped smaller plates that fill in the spaces between the root radii. The stalk is generally placed a little eccentrically to the high, most prominent or primary root member. This member usually bifurcates at each end and each division branches once more; from the lower sides of this medial member are given off from 1 to 3 other secondary branches, each of which again bifurcates distally (see text-figure 43). There are, therefore, around the inner side of the collar, from 12 to 18 and even as many as 22 branchlets, between each 2 of which is situated a more or less large opening to the chambers, there being as many of these openings, 4 to 11, as there are chambers. The roots between each bifurcation consist of from 3 to 5 plates, the place of division of the primary root member being occupied by a single wedge-shaped piece, while those on the sides usually have a double plate occupying the same position. The axial canal of the stalk does not pass through the base of the bulb and into the medio-basal chamber, but ends in the primary root member, where it branches and connects with the canals of all the roots. The latter canals pass through all the bifurcations and continue into the outer wall communicating with the open space between the two parts of the walls. In this way vascular and nervous connection is maintained between all parts of the bulb.

The stalk is inserted into the root as a wedge (see figure 44). The length of the stalk is unknown, as the bulbs never preserve a piece longer than 15 mm. This part has thin segments, with the articular surfaces radially striate, as in crinoids, and is penetrated by a small round or pentagonal axial canal, with 5 short linear radii.

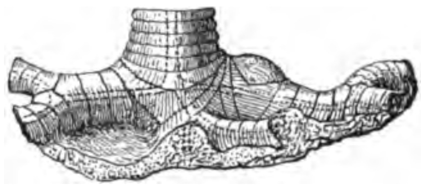


FIG. 44.—Side view of the base of *C. ulrichi*, showing how the stalk is wedged into the roots; the interior canals of the roots are indicated by broken lines. × 2.

Attached to *Camarocrinus* are sometimes found roots like those of many crinoids, as, for instance, *Eucalyptocrinus*, and these at one time were supposed also to belong to this genus, the bulb of course then being regarded as the theca of the animal. These roots, however, belong to another crinoid, as the sutures between the plates are not wavy as in *Camarocrinus*.

Genotype, *C. stellatus* Hall. The above definition, however, is based largely on *C. ulrichi*.

Conclusions.—It has been seen from the remarks of Dr. Jahn that he does not regard all the specimens of *Lobolithus* as belonging to *Scyphocrinus*, but thinks that some may belong to other genera, and that at times the former are found where the latter are unknown. On the other hand, in America, no crinoids except *Edriocrinus*, which is a stalkless form directly attached by the theca to foreign bodies, are ever found associated with *Camarocrinus*, while no *Scyphocrinus*, as defined by Zenker, are known on this side of the Atlantic. *Scyphocrinus* Hall is a different genus and was proposed by that author without knowledge of Zenker's previous use of the same name. Then again, the widely differing geological horizons of occurrence between Bohemia and the Appalachians, and between the latter and Tennessee and Indian Territory, make it certain that these bodies, if they are root appendages, can not all belong to *Scyphocrinus*. In Bohemia the fossils in question occur in the transition zone between Barrande's division E e1 and E e2, which in the American geological sequence means about the Rochester shale. The next horizon in which *Camarocrinus* is found is the Manlius, which is at the top of the Siluric. In other words, between the Bohemian occurrence and the first American record there are the Lockport, Guelph, Salina, and Bertie formations. No occurrence of this genus is known in the highest Manlius and all of the Coeymans, but it reappears in greatest abundance in the lower New Scotland in Tennessee and Indian Territory.

The geologic occurrence of these bodies—their gregarious habit, with the great majority of the bulbs having their stalked end downward—leads naturally to the conclusion that *Lobolithus* or *Camarocrinus*, as found, represents nearly all of the animal, and that these bulbs must be thecæ either of cystids or crinoids. This was the view set forth by the great paleontologist Barrande, and was also independently reached by Ulrich and the writer. That *Camarocrinus* is, however, not a cystid theca nor crinoid calyx is clearly indicated by the absence of ambulacra, mouth, and anus. Further, the axial canal of the stalk does not pass directly into the medio-basal chamber; otherwise this cavity could be interpreted as the visceral cavity. On the other hand, the insertion of the stalk into the root complex, all of which divisions have a central canal, and the fact that the walls of the camaræ are nothing more than modified root-branches connecting with the second series of roots, seem to furnish conclusive evidence that *Camarocrinus* can be nothing more than the highly specialized root of a crinoid.

If this view apparently explains the true nature of *Camarocrinus*, the question naturally arises, How can the vertical position of these fossils in the strata be harmonized with the conclusion? The objection has been made that *Camarocrinus* is too heavy for the float of a crinoid, and while this appears to be true of the fossilized condition, it does not apply to the living state. The writer has noted the weight of the basal portion of a siliceous specimen of average size (estimated to be 3½ inches in diameter, see plate XLII, figure 4), and cleaned of all adhering calcareous matter by etching in hydrochloric acid. The siliceous matter in such a specimen, it is estimated, will not exceed 4 ounces—a weight certainly not too great for a float of this size.[1]

[1] This paragraph was shown to a critical friend and he holds that the deductions as stated are in error for the following reasons: (1) A siliceous pseudomorph, after it has been etched, is lighter than the original calcareous structure, because the acid honeycombs the walls and also because siliceous pseudomorphs are often mere skeletons of the outer and inner sides of the walls, leaving the greater central space free of material. *Answer:* In the specimen selected for ascertaining its original weight, the walls are nearly solid, though there is some honeycombing due to etching. Further, the fragment weighed is the basal portion, therefore the heaviest part of the bulb.

Moreover, if *Camarocrinus* is a float, why is it that the great majority of the bulbs are found in the strata with the stalk end downward? Assuming for the present that these bodies are the air-filled floats of some crinoid, it must be granted, on the basis of the wide dissemination of other shelled organisms with hollow cavities (as the shells of *Spirula, Nautilus,* and *Ammonites*) that the bulbs of *Camarocrinus* would continue to float for some time (possibly for hundreds of miles) after the crown and stalk had decayed. The latter portions would be dropped over one part of the sea bottom, while the bulb would sink later in another region. On account of its double and interlocked walls and interior braces, the dead bulb would continue to drift with the currents, as in the living condition, i. e., with the stalk downward, because the weightiest part is at this

---

The weight of this specimen was multiplied by the number of equal fragments estimated to make a bulb 3½ inches in diameter. It therefore seems to the writer that the weight is considerably overestimated.

The weight of the calcareous skeleton in a dry specimen of *Echinus esculentus* L., nearly 4 inches in diameter and without spines and jaws, is 2 ounces. Another dry echinus, *E. gracilis,* with spines, jaws, and the dried remainder of the soft parts, nearly 3½ inches in diameter, weighs but $1\frac{5}{8}$ ounces. These figures indicate that a dry *Camarocrinus* before mineralization probably did not weigh 4 ounces.

(2) A specimen of *Camarocrinus* 3½ inches in diameter, he estimates, would contain about 8 cubic inches of air, and therefore lacked the capacity necessary to float as large and heavy a crinoid as *Scyphocrinus.* This estimate is in error, as the contents of such a bulb is about 22 cubic inches.

(3) A specimen of the crown and stem of a living *Isocrinus decorus* (Havana) 16 inches long, also in the dry state, weighs but three-sixteenths of an ounce. If *Scyphocrinus* is 4 times as large and 8 times as heavy as the *Isocrinus,* then the dry skeleton of the former would weigh only 1½ ounces.

The writer realizes that these estimates may not be the real weight in the living organisms, and also that the weight of the soft parts is not considered (these, however, need hardly be considered, as the specific gravity of the soft parts is but one-tenth heavier than water). The only point he wishes to emphasize is the relative weights of the parts in relation to the floating capacity of the bulb. A sphere 3½ inches in diameter has a cubical content of a little more than 22 inches. A cubic inch of water weighs 252.45 gr. A 3½-inch sphere will therefore displace or float above the water (distilled) a weight equal to nearly 13 ounces. In sea water it will be nearly twice as much, and if *suspension* in sea water alone is considered, it will be nearly two and a half times that of floating it in distilled water. A dry skeleton of a *Scyphocrinus* with a crown about 1 foot in length and a stalk 3 feet long, with a 3½-inch bulb, is estimated to weigh not over 6 ounces. When one considers that these bulbs attain a diameter of 5 inches, and even larger in Bohemia, while the *Scyphocrinus* crown used in the above estimates is one of the largest, it is seen that these bulbs are abundantly able to suspend a stalk and crown of so ponderous a species as *Scyphocrinus elegans.*

end. As the outer integument of the bulb decayed, the chambers would fill with water, thus causing it to sink gradually to the bottom in its natural position. This mode of segregation would also explain, not only why these bulbs are generally found with the stalk end downward, but also why no crinoid calyxes or crinoidal fragments are found (at least very rarely) associated. This hypothesis assumes that the crowns and stalks must in some other area be as plentiful as are the bulbs which make beds replete with them, in Indian Territory extending for 100 miles. In Tennessee, these bulbs are also abundant, and their geographic extent is probably not less than 50 miles. In the Appalachian region *Camarocrinus* is known plentifully only at one locality. Yet in no place throughout the formations in which these bulbs occur are there corresponding beds replete with crowns, stalks, or even accumulations of the separated ossicles. This is the one weak point in the argument that *Camarocrinus* is the float or specialized root of a crinoid.

To assume that these bodies were anchored in the mud with the stalk directed upward seems to be at variance, not only with their position in the rocks (the great majority are found in a reversed position), but also with their structure. The rounded end of the bulb is full of pores, and what purpose could these have served buried in the mud? In old examples, where all that portion which could have protruded above the mud has the pores covered over by a secondary amorphous coating, this is especially difficult to understand. On the other hand, if these bulbs were anchored in the mud during the life of the crinoid, some calyxes or a great mass of crinoidal fragments should have been found with them, yet this is not the case.

If, as the writer believes, *Camarocrinus* is the float of a crinoid, it appears to be the only one known either in the fossil or living state. It is a well-known fact, however, that crinoids "present a constant tendency to relinquish the attached mode of life and to lose that typical organ, the stem."[1] In Mesozoic times several genera of crinoids are known to have been devoid of columns and some are thought to have been pelagic.

Lichenocrinus represents the nearest approach of a modified crinoid root to *Camarocrinus*. It, too, is camerate, the radiating striæ seen on weathered examples being vertical plates extending upward from the attached base to the inner side of the surface plates. Dr. E. O. Ulrich has also demonstrated their existence for himself by means of thin sections, and has illustrated these features for Mr. S. A. Miller

[1] Bather, op. cit., p. 134.

in *L. tuberculatus*.[1] However, this form when compared with *Camarocrinus* is wholly different, as the base of *Lichenocrinus* is attached to foreign bodies, while to the upper side is attached a long, slender, and complicated stem, 3 to 4 inches in length. Many excellent specimens are known with the stalk attached, but none has a crown.

Even though no other example of root modification similar to *Camarocrinus* is known, this fact alone can not be taken as disproving Bather's statement[2] in regard to these bulbs that "another curious modification, perhaps connected with a free-floating existence, was presented by the root of *Scyphocrinus* [= *Lobolithus* = *Camarocrinus*]."

The suggestion of two writers that these bulbs may have functioned as receptacles in which the young were developed finds no support in other crinoid structures. The fertilized eggs of crinoids pass from the pinnules into the water singly or in bunches, but are not known to enter a special receptacle for further development (See Springer, ante, page 259).

Summary.—*Camarocrinus* thus appears to be the float of an unknown crinoid that was held together after the death of the individual by the firmly interlocked double walls of the exterior and interior, while the crown and stalk dropped away. Under this hypothesis, the float drifted with the sea currents, was finally filled with water, and the attenuated end being heavier, sank in that position to the sea bottom. The occurrence of these bulbs thus in the strata now gives one the impression that they represent the entire animal and are preserved in the original position of growth.

The writer realizes that the last word has not been said in regard to *Camarocrinus,* and the present work is offered with the hope that some paleontologist will attack the problem from another point of view. The supposition that *Camarocrinus* is a degenerate crinoid in which the roots represent cirri, the medio-basal chamber the calyx, and the double walls of the camaræ the equivalent of the arms, seems to find no support in the detailed structure of these bulbs.

CAMAROCRINUS STELLATUS Hall

(PLATE XLIV, FIGURES 1–5)

Camarocrinus stellatus HALL, Twenty-eighth Rep. N. Y. State Mus. Nat. Hist., Mus. ed., 1879, p. 207, pl. 35, figs. 1–8. Extract, 4°, 1880, p. 5, pl. 35, figs. 1–8.

[1] Op. cit., p. 135.

[2] *Jour. Cincinnati Soc. Nat. Hist.*, v, 1882, p. 229, pl. 9, figs. 6, 6a.

This species is readily separated from *C. saffordi* by its more depressed form, larger and more open basal area, and the finely granular nature of the plates of the outer integument. These granules flow variously together and the plates are more or less stellate. In some individuals this character is more marked than in others, so that the degree of stellation is variable and individual, but it never takes place so prominently as in some examples of *C. ulrichi stellifer*.

Formation and locality.—Not common in the Tentaculite limestone of the upper Manlius at Schoharie, New York. Rare in the lower portion of the same formation at Devil's Backbone, near Cumberland, Maryland, and very common near the middle of the Manlius in the quarries of the B. & O. R. R. near Keyser, West Virginia. The largest specimen has a diameter of 12.5 cm.

Cat. numbers 35,080, 35,081, U. S. N. M.

CAMAROCRINUS SAFFORDI Hall

(PLATE XL, FIGURE 10)

Camarocrinus saffordi HALL, Twenty-eighth Rep. N. Y. State Mus. Nat. Hist., Mus. ed., 1879, p. 208, pl. 36, figs. 1–6; pl. 37, figs. 1, 2. Extract, 4°, 1880, p. 6, pl. 36, figs. 1–6; pl. 37, figs. 1, 2.

Camarocrinus clarkii HALL, ibidem, p. 209, pl. 36, figs. 7, 8; pl. 37, fig. 3. Extract, p. 7, pl. 36, figs. 7, 8; pl. 37, fig. 3.

This species is distinguished from *C. stellatus* by the more elevated or balloon-shaped theca, as well as by the serrated suture lines of the plates and the few scattered openings between the latter. *C. clarkii* is not a good species, as large collections show considerable variation in the form, but more particularly in the number of camaræ in all the species. It is simply an unusually lobate specimen having 11 chambers. *C. ulrichi* is still more balloon-shaped, with the outer integument basally extended into a high collar, and with numerous minute pores at most of the angles of the thecal plates.

Formation and locality.—In western Tennessee there appears to be no zone equivalent to the New York Manlius, as the Meniscus, or, rather, Foerste's Brownsport limestone, is immediately followed by the Linden or Helderbergian of about the age of the New York Uppermost Coeymans or basal New Scotland. In 1897 the writer found three specimens of *C. saffordi* at Allen's Mill, on the Birdsong, in Benton county, but the exact equivalent for the horizon of these fossils in the New York section remains undetermined. During the year 1903 Mr. Foerste collected many specimens of this species in unmistakable Helderbergian strata of the age of the New Scotland. These were collected in the lower 50 feet of the Linden formation

(= New Scotland), on Horse creek, near Chalybeate spring, and on Tennessee river, near Pyburn landing, or opposite White Sulphur spring.[1] Hall's material is from Hardin county, Tennessee. Recently Mr. R. S. Bassler found this species in beds of New Scotland age, just below the Clear Creek chert along the Mississippi, north of Cape Girardeau, Missouri.

Cat. number 27,760, U. S. N. M.

CAMAROCRINUS ULRICHI Schuchert

(PLATE XL, FIGURES 6-8; PLATES XLI-XLIII)

Camarocrinus ulrichi SCHUCHERT, Amer. Geol., XXXII, 1903, p. 239.

This species is more pyriform or balloon-shaped than *C. saffordi,* and the theca is usually considerably pinched and prolonged basally into a high collar, evidently for the greater protection of the basal openings. The plates are very much as in *C. saffordi,* and where stellation has not set in, they adjoin with very finely serrated sutures, but the pores between the plates are much smaller and are far more abundant than in the latter species. In some individuals stellation begins by the insertion of small, spicular pieces between and around the pore openings, and above the larger plates over the dome of the theca. In different individuals is found nearly every stage of progression from the non-stellate form to the prominently stellate *C. ulrichi stellifer.* This detail is more clearly shown in the illustrations on plate XL.

Young or small specimens of *C. ulrichi* have the depressed form, with the large and not sharply delimited basal area of *C. stellatus,* showing progressive development toward a more balloon-shaped theca, with a pinched and restricted basal termination. The largest known specimen has a diameter of 12 cm.

Formation and locality.—Very common in the lower portion of the Helderbergian (Hunton formation) of Indian Territory, where Dr. Ulrich found them at many localities for a distance of 100 miles. Some of the best localities are 3 miles northeast and 4 miles south of Daugherty, and 1⅛ miles and 2 miles south of Franks.

It gives the writer great pleasure to name this species for its discoverer, Dr. E. O. Ulrich, one of America's most distinguished paleontologists, and an indefatigable collector.

Cat. numbers 35,082–35,085, U. S. N. M.

---

[1] See Foerste, *Jour. Geol.,* XI, 1903, pp. 683–685, 714.

C. ULRICHI STELLIFER n. var.

(PLATE XL, FIGURE 9; PLATE XLI, FIGURE 6)

This variety is distinguished by the great prominence of the star ornamentation of the theca, caused by the fusing together of many smaller pieces into large plates, where the pores appear to pass through the plates and not between them. In this condition the pores may remain as simple, round perforations, or 2 of adjoining angles may be drawn out into a narrow slit, giving the impression of true dichopores. In other individuals the stellation seems to leave very large openings, much like those in the calcareous skeleton of the common starfish, *Asterias forbesii*. The size of some of these openings is undoubtedly increased by weathering, but they were originally very much larger than those in *C. ulrichi*.

Formation and locality.—This variety is always found very poorly preserved, and distorted by rock pressure. The extremely loose structure of the calcareous skeleton may have been the cause of the smashed condition of these individuals, and their consequent fragmentary nature when weathered out on the surface. Found associated with *C. ulrichi*.

Cat. numbers 35,086–35,088, U. S. N. M.

Explanation of Plate XXXIV

(Photographs retouched by Miss Frances Wieser and Dr. E. O. Ulrich.)

Figs. 1, 2. *Callocystites jewettii* Hall .... p. 243

Fig. 1. The antanal side, showing many brachioles.

Fig. 2. The anal side of same specimen, showing the anal pyramid. Rochester shales, Grimsby, Ontario. Collection of Dr. B. E. Walker, Toronto.

Fig. 3. *Callocystites canadensis* (Billings) .... p. 245

The side, with the anal pyramid to the right. × 2.
Rochester shales, Grimsby, Ontario. Collection of Dr. B. E. Walker.

Figs. 4, 5. *Apiocystites elegans* Hall .... p. 212

Fig. 4. The anal side. × 2.

Fig. 5. Same specimen, from the antanal side. × 2.
Rochester shales, Grimsby, Ontario. Collection of Dr. B. E. Walker.

Figs. 6–8. *Tetracystis fenestratus* (Troost ms.) .... p. 219

Fig. 6. View showing the upper left-hand pectinirhomb, with the anus to the right. × 2. Holotype, 35,091.

Fig. 7. Same, from the anal side. × 2.

Fig. 8. Same, from the antanal side. × 2.
Brownsport limestone, Decatur county, Tennessee.

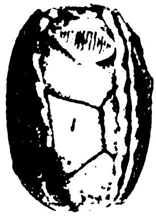
Figs. 9, 10. *Tetracystis chrysalis* n. sp. .... p. 218

(See also Plate XL, figures 1–3.)

Fig. 9. View showing upper left-hand pectinirhomb. × 2.

Fig. 10. Same specimen from the antanal side. × 2. Holotype, 35,063.
Manlius formation, near Keyser, West Virginia.

1



6

2

3

4

5

7

9

8

10

SILURIC CYSTIDS

HELIOTYPE CO., BOSTON

EXPLANATION OF PLATE XXXV

(Photographs retouched by Miss Frances Wieser. Unless otherwise stated, the specimens figured are from the Manlius formation, near Keyser, West Virginia.)

FIGS. 1–3. *Trimerocystis peculiaris* n. sp. .... p. 239

Fig. 1. View of the holotype (35,064) from the anal side.

Figs. 2, 3. Same specimen seen from the sides.

FIGS. 4, 5. *Pseudocrinites subquadratus* n. sp. .... p. 234

Two views of the holotype. × 2. 35,067.

From Devil's Backbone, near Cumberland, Maryland.

FIGS. 6, 7. *Pseudocrinites elongatus* n. sp. .... p. 235

Two views of the holotype, 35,065.

From Martin's mountain, Bedford county, Pennsylvania.

FIGS. 8, 9. *Pseudocrinites stellatus* Schuchert .... p. 232

Two side views of the holotype, 35,069.

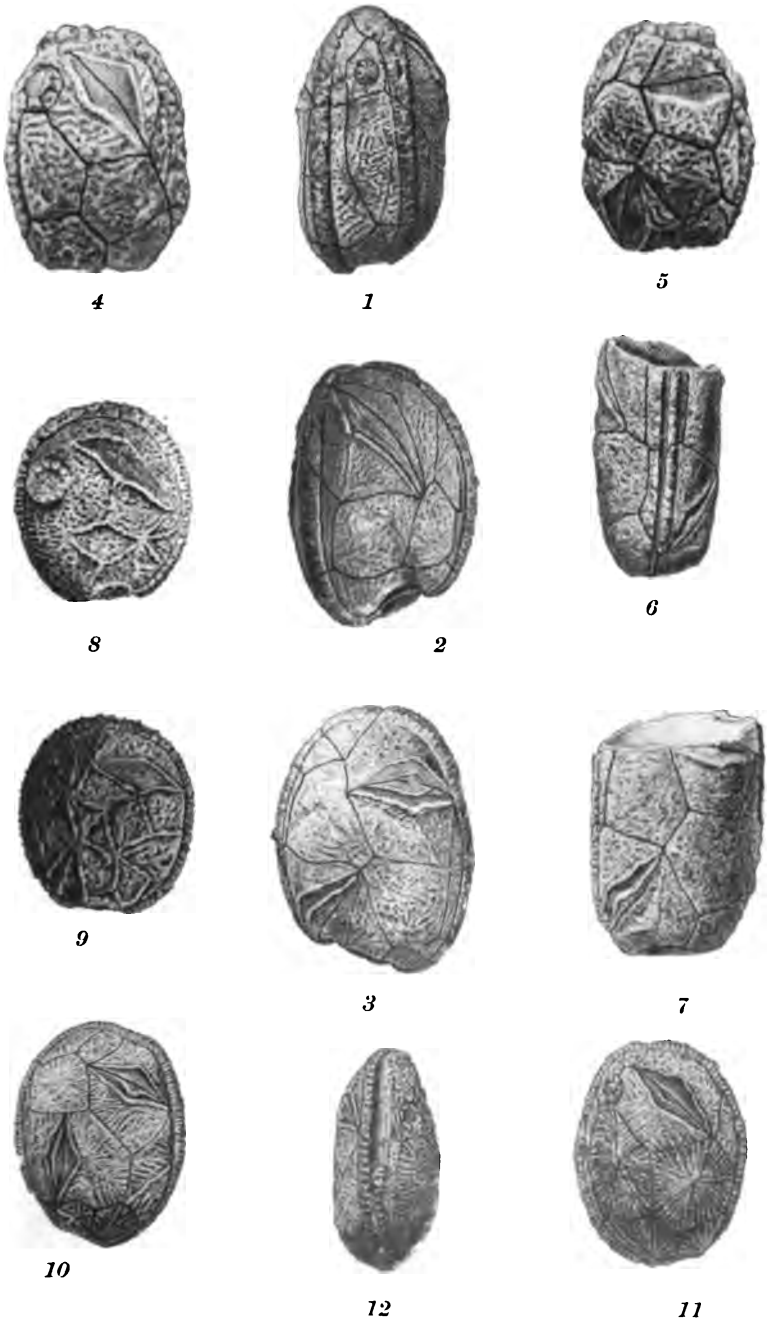
(See also PLATE XXXIX, FIGURE 7.)

FIGS. 10–12. *Pseudocrinites abnormalis* n. sp. .... p. 231

Fig. 10. View of the sides having the abnormal position of the lower pectinirhomb.

Fig. 11. Opposite side of same specimen.

Fig. 12. End view of same. Holotype, 35,068.



SILURIC CYSTIDS

Explanation of Plate XXXVI

(Photographs retouched by Miss Frances Wieser. The specimens figured are from the Manlius formation, near Keyser, West Virginia.)

Figs. 1–3. *Pseudocrinites perdewi* Schuchert.........................p. 23[illegible]

(See also Plate XXXIX, figures 8–10.)

Fig. 1. Side view of a young specimen. × 2. Paratype, 35,072.

Figs. 2, 3. Two views of the holotype. Natural size. 35,072.

Figs. 4–7. *Pseudocrinites clarki* Schuchert...........................p. 233

(See also Plate XXXIX, figure 14.)

Figs. 4–6. Three views of the holotype, an average adult individual. 35,070.

Fig. 7. A very large specimen of this species. The plates around the pectinirhomb are somewhat broken. 35,070.

Figs. 8–12. *Pseudocrinites gordoni* Schuchert........................p. 22[illegible]

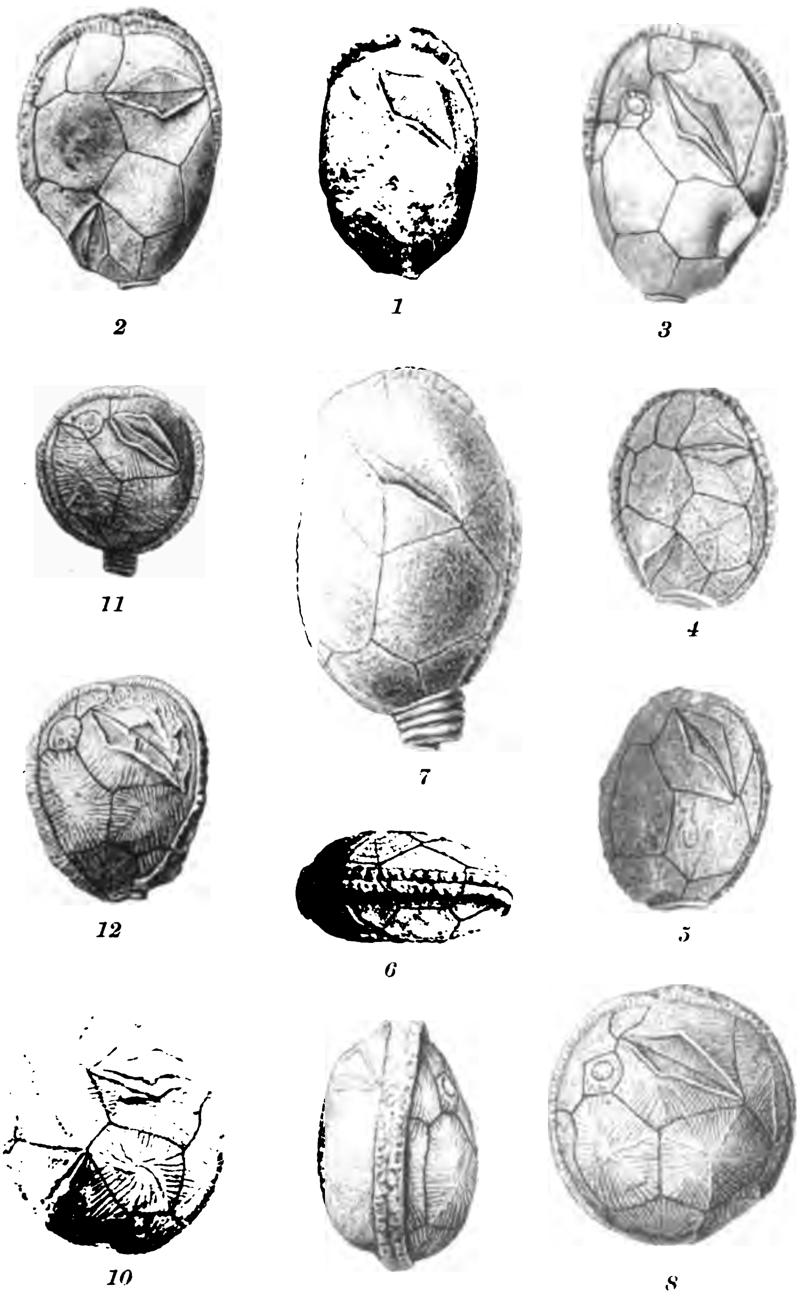
(See also Plate XXXIX, figures 11–13.)

Figs. 8, 9. Two views of the holotype, a specimen somewhat larger than usual. 35,071.

Fig. 10. Another specimen. 35,071.

Fig. 11. A smaller but adult individual of the rounder variety. 35,071.

Fig. 12. An elongate individual, somewhat abnormal in having the ambulacra drawn over on the anal side more than is usual. 35,071.



SILURIC CYSTIDS

HELIOTYPE CO., BOSTON

EXPLANATION OF PLATE XXXVII

(Photographs retouched by Wieser and pen and ink camera-lucida drawings by McConnell. The specimens figured are from the Manlius formation, and unless otherwise stated are from near Keyser, West Virginia.)

FIG. 1. *Pseudocrinites claypolei* n. sp. .... p. 232

Fig. 1. The holotype; the ambulacral plates are exfoliated. × 2. 35,066.

From Clark's Mills, near New Bloomfield, Pennsylvania.

FIGS. 2, 3. *Lepocrinites manlius* n. sp. .... p. 214

(See also PLATE XXXIX, FIGURES 15, 16.)

Figs. 2, 3. Two views of the holotype. × 2. 35,062.

FIGS. 4–8. *Jaekelocystis hartleyi* Schuchert .... p. 224

Fig. 4. View of the holotype; a large specimen. Anal opening to the right. × 2.

Fig. 5. A smaller specimen with the anal opening to the left. × 2.

Fig. 6. Camera-lucida drawing of the oral end to show the arrangement of the ambulacral plates, the ambulacralia (somewhat restored), brachiole attachments, and the plate with the madreporite; the latter lies in the depression of the large plate on the left of the figure. × 8.

Fig. 7. The anal pyramid; the positions of the bounding plates, 13, 14, 7, 8, are indicated. × 8.

Fig. 8. Plates 14 and 15, with the discrete-pectinirhombs; the dichopores on plate 14 are deeply situated and do not show on the surface. × 8.

FIGS. 9, 10. *Jaekelocystis papillatus* n. sp. .... p. 225

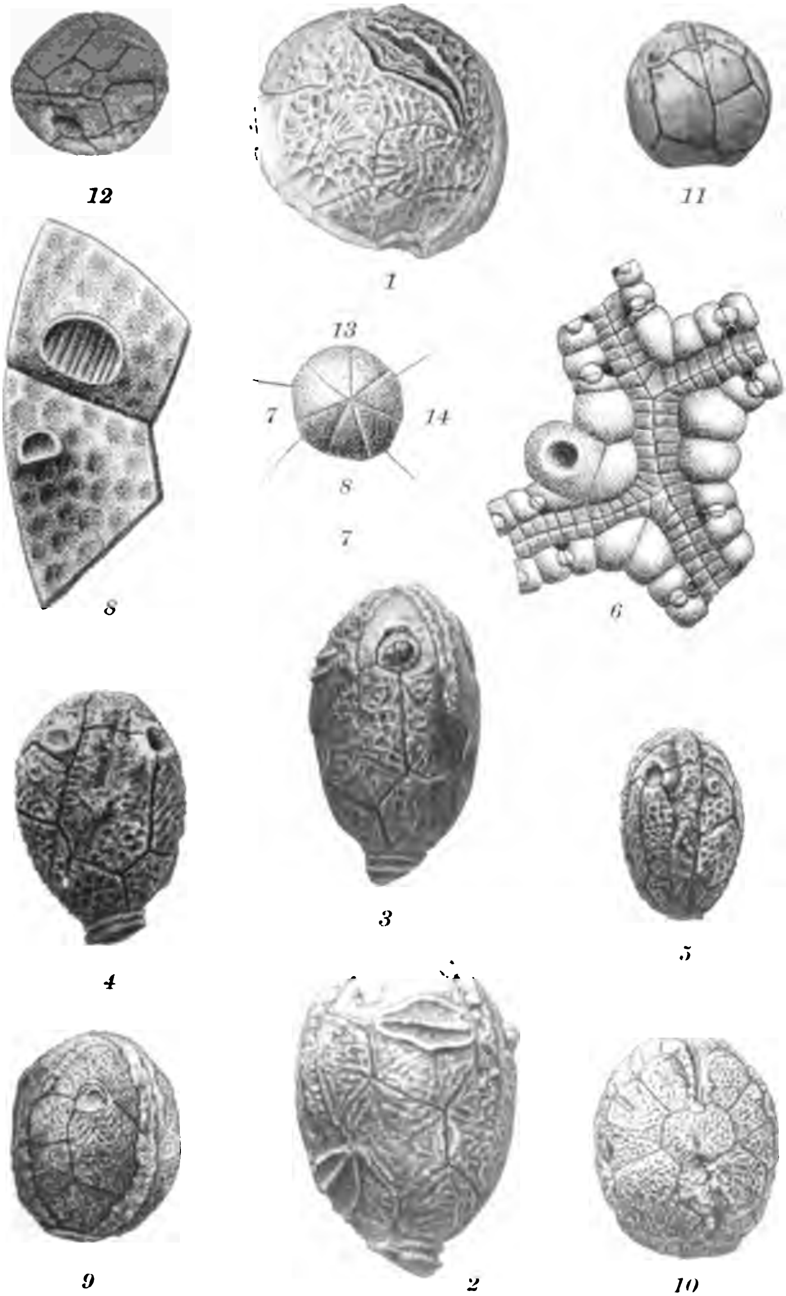
Fig. 9. Anal aspect of the paratype. × 2.

Fig. 10. Antanal view of the holotype; pectinirhomb 14–15 is faintly indicated on the left. × 2.

FIGS. 11, 12. *Jaekelocystis avellana* n. sp. .... p. 226

Fig. 11. View of the holotype, with the anal opening to the left and pectinirhomb of plates 14–15 to the right. × 3. 35,056.

Fig. 12. Same specimen seen from the top, showing the 2 small discrete-pectinirhombs, the central madreporite, and the large anal opening. × 3.



SILURIC CYSTIDS

Explanation of Plate XXXVIII

(Photographs retouched by Miss Frances Wieser. The specimens figured are from the Manlius formation.)

(See also Plate XXXIX, figures 1–4.)

Fig. 1. A large specimen, seen from the anal side; most of the sculpturing consists of the ambulacral branches. × 2. 35,058.

Fig. 2. The same individual, seen from the top. × 2.

Cash valley, near Cumberland, Maryland.

(See also Plate XXXIX, figures 5, 6.)

Figs. 3, 4. The holotype, seen from the anal side and the top. × 2. 35,053.

Near Keyser, West Virginia.

Fig. 5. The entire stalk, terminating in the roots at one end, and at the other preserving a few of the thecal plates, seen from the interior. Natural size. 35,077.

Devil's Backbone, near Cumberland, Maryland.

Fig. 6. The holotype, seen from the side. × 2. 35,054.

Near Keyser, West Virginia.

3

1

6

2

4

5

SILURIC CYSTIDS

Explanation of Plate XXXIX

(Pen and ink drawings, after the camera-lucida, by J. C. McConnell.)

Figs. 1–4. *Sphærocystites multifasciatus* Hall........................p. 250

(See also Plate XXXVIII, figures 1, 2.)

Fig. 1. The two circles of plates composing the anal pyramid; the numbers indicate the bounding thecal plates. About × 5.

Fig. 2. Part of an ambulacrum, showing one row of ambulacral plates, the ambulacralia, and remnants of brachioles. About × 10.

Fig. 3. An incomplete brachiole. About × 10.

Fig. 4. Deltoid 23, with the madreporite and hydropore closed by its pyramid. About × 10. All 35,052.

Figs. 5, 6. *Sphærocystites globularis* Schuchert......................p. 252

(See also Plate XXXVIII, figures 3–5.)

Fig. 5. The anal pyramid and the bounding thecal plates indicated by numbers. About × 5.

Fig. 6. Part of an ambulacrum, showing the ambulacral and ambulacralia plates, and the points of attachment for the brachioles. About × 5. Both 35,053.

Fig. 7. *Pseudocrinites stellatus* Schuchert............................p. 232

(See also Plate XXXV, figures 8, 9.)

Fig. 7. Part of an ambulacrum, showing one row of ambulacral plates, the brachiole facets, and the ambulacralia with their intermediate large plates. About × 5. 35,069.

Figs. 8–10. *Pseudocrinites perdewi* Schuchert.........................p. 236

(See also Plate XXXVI, figures 1 to 3.)

Fig. 8. Deltoid 23, with the madreporite and the small hydropore; the double row of small plates and the ambulacralia. About × 5.

Fig. 9. Portion of an ambulacrum in a young specimen. About × 5.

Fig. 10. Same as fig. 9; seen from the side to show the high elevation of ambulacralia. About × 5. All 35,072.

Figs. 11–13. *Pseudocrinites gor[illegible]i* Schuchert.......................p. 229

(See also Plate XXXVI, figures 8–12.)

Fig. 11. Portion of an ambulacrum. About × 5.

Fig. 12. A nearly complete brachiole. About × 5.

Fig. 13. Deltoid 23 crowded into the ambulacral plates, showing the madreporite and hydropore. About × 5. All 35,071.

Fig. 14. *Pseudocrinites clarki* Schuchert.............................p. 233

(See also Plate XXXVI, figures 4–7.)

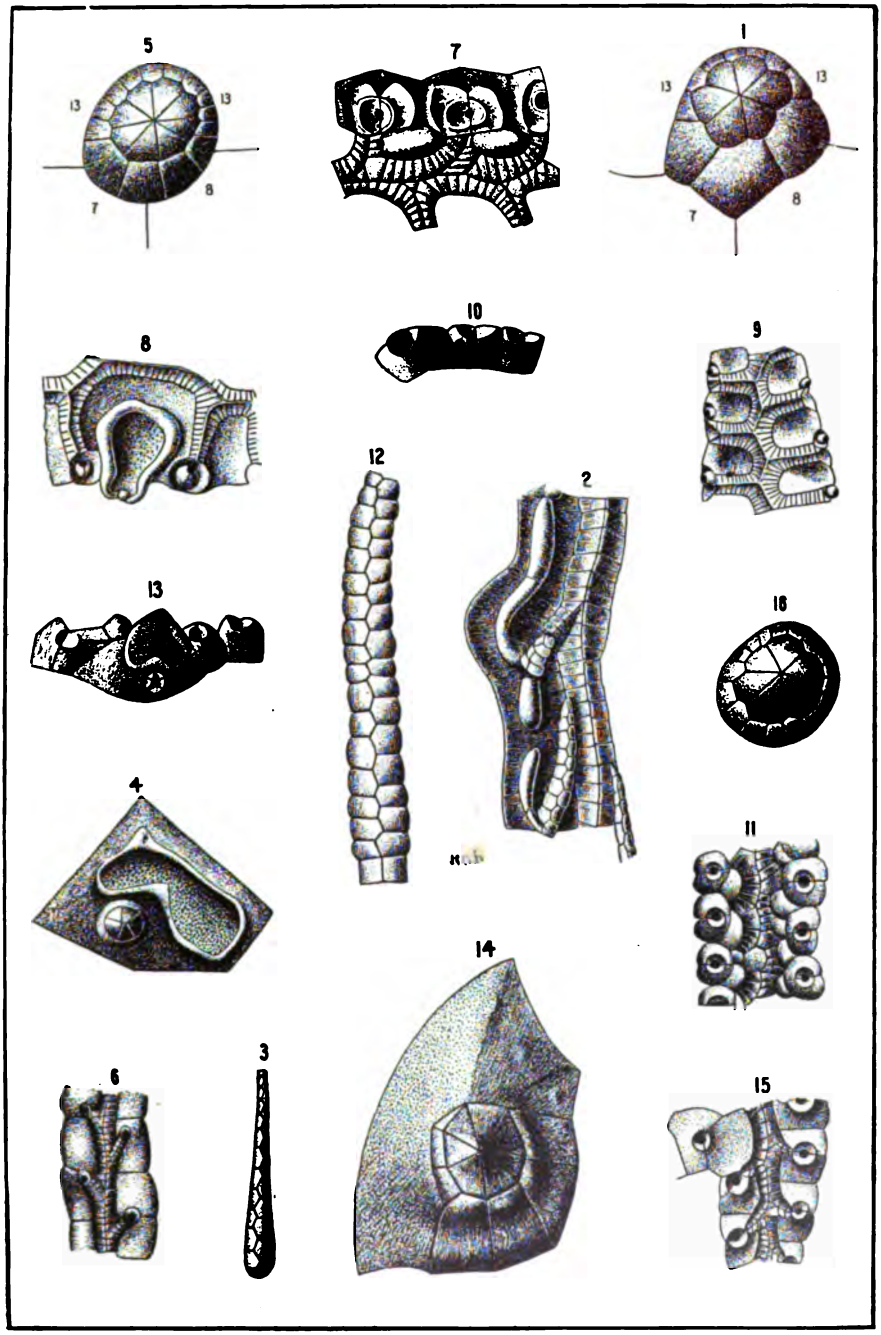
Fig. 14. Plate 13 on the left and the incomplete circle of 7 small plates bounding the anal pyramid of 7 pieces. About × 5. 35,070.

Figs. 15–16. *Lepocrinites manlius* n. sp..............................p. 214

(See also Plate XXXVII, figures 2, 3.)

Fig. 15. An ambulacrum near the oral opening. About × 5.

Fig. 16. The 2 circles of pieces composing the anal pyramid. About × 5. Both 35,062.



SILURIC CYSTIDS

Explanation of Plate XL

(Pen and ink camera-lucida drawings by J. C. McConnell.)

Figs. 1–3. *Tetracystis chrysalis* n. sp. ....p. 218

(See also Plate XXXIV, figures 9, 10.)

Fig. 1. Portion of an ambulacrum; the transverse markings in the ambulacral groove indicate the position of the ambulacralia, but not the plates themselves. About × 5.

Fig. 2. The anal pyramid and the boundary thecal plates 13, 14, 7, 8. About × 5.

Fig. 3. Deltoid 23, with the madreporite and hydropore. About × 5.

Figs. 4, 5. *Anomalocystites cornutus* Hall. ....p. 206

(See also text-figures.)

Fig. 4. The complete stalk. Somewhat less than × 3.

Fig. 5. One of the free arms seen from the adambulacral side. About × 5.

Coeymans limestone, Litchfield, Herkimer county, New York.

Figs. 6–8. *Camarocrinus ulrichi* Schuchert. ....p. 271

(See also Plates XLI–XLIII.)

Fig. 6. The plates of the bulb, as seen on the top or rounded side of a small specimen. About × 5.

Fig. 7. More convex plates in another specimen in the same position as fig. 6. About × 5.

Fig. 8. Similar plates in a small specimen, indicating the beginning of stellation. About × 5.

Helderbergian, 3 miles northeast of Daugherty, Indian Territory.

Fig. 9. *Camarocrinus ulrichi stellifer* n. var. ....p. 271

(See also Plate XLI, figure 6.)

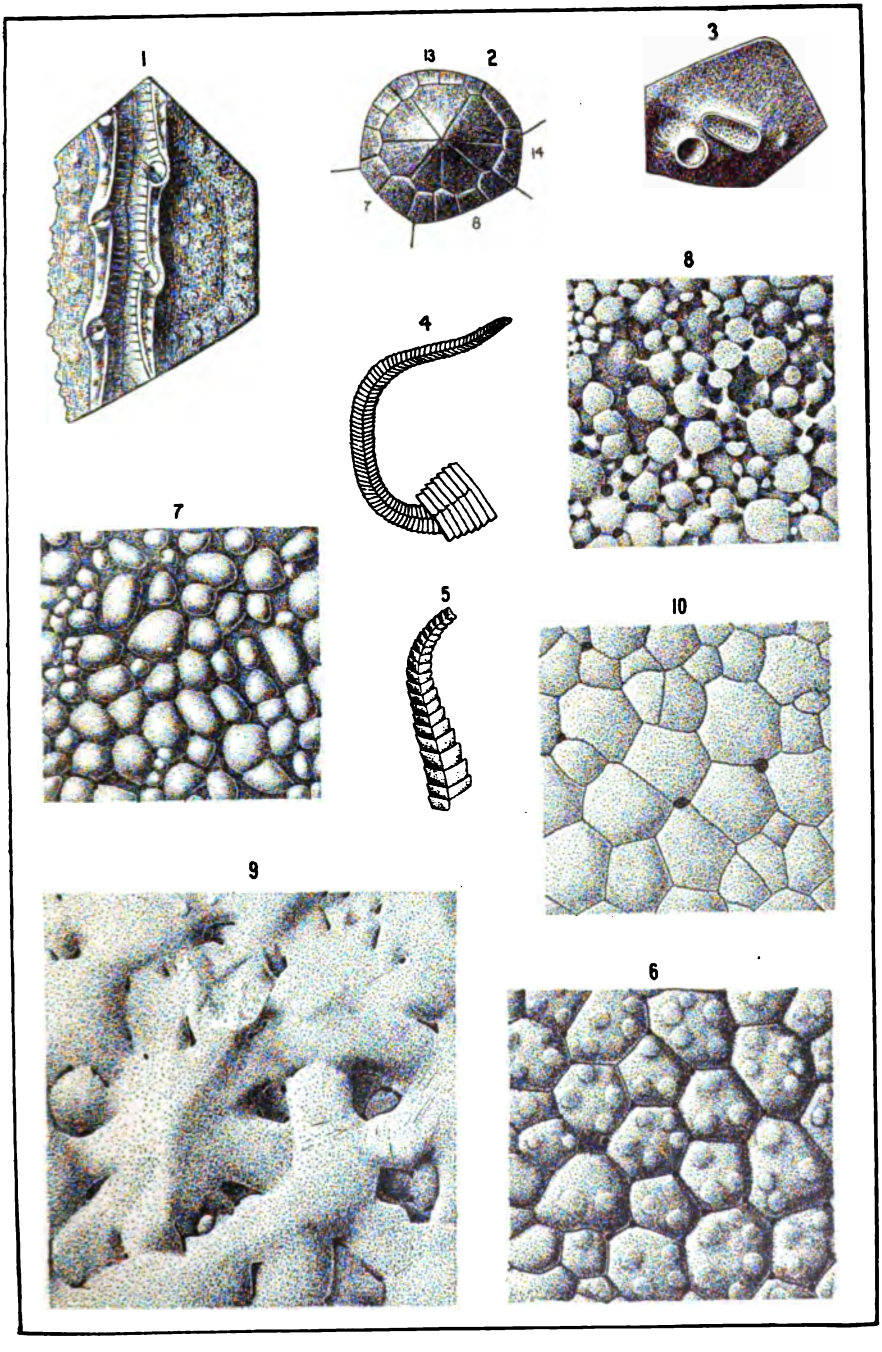
Fig. 9. The stellate surface of this variety, also showing the slit-like openings through the test. About × 5. 35,086.

Helderbergian, S. W. ¼ sec. 15, T.2S., R.2E., Tishomingo quadrangle, Indian Territory.

Fig. 10. *Camarocrinus saffordi* Hall. ....p. 270

Fig. 10. The surface on the rounded end of a large bulb. About × 5. 27,760.

Helderbergian, Allen's Mills on the Birdsong, Benton county. Tennessee.



CAMAROCRINUS AND CYSTIDS

Explanation of Plate XLI

(Photographs retouched by Miss Frances Wieser. The illustrations on this plate are one-third smaller than the specimens.)

Figs. 1-5. *Camarocrinus ulrichi* Schuchert.......................... p. 271

(See also Plates XL-XLIII.)

Fig. 1. A small, somewhat elongate specimen, with the high collar so characteristic of this species. 35,085.

Fig. 2. A depressed, decidedly lobate specimen. 35,084.

Fig. 3. Another specimen like Fig. 2, to show the primary root and its branches; also the camaræ openings between the final bifurcations; there are 9 of these openings. 35,085.

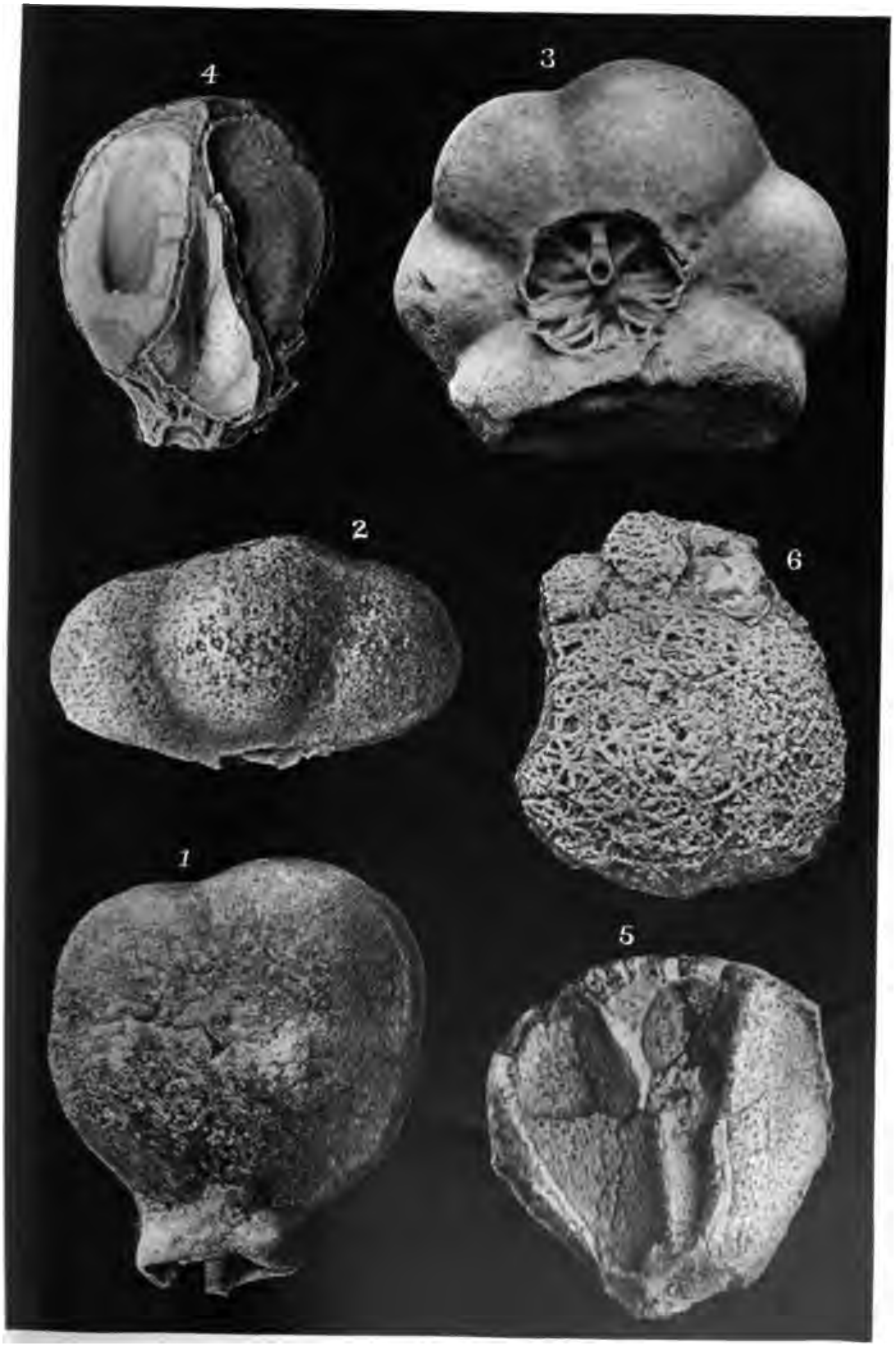
Fig. 4. A siliceous specimen broken open, showing the medio-basal chamber and 2 camaræ. 35,084.

Fig. 5. A weathered specimen, showing the porous nature of the interior walls. 35,085.

Fig. 6. *Camarocrinus ulrichi stellifer* n. var......................... p. 271

(See also Plate XL.)

The surface of a crushed specimen; the holotype, 35,088.



CAMAROCRINUS

Explanation of Plate XLII

(Photographs retouched by Miss Frances Wieser. The illustrations on this plate are one-third smaller than the specimens. From the Helderbergian of Indian Territory.)

Figs. 1–4. *Camarocrinus ulrichi* Schuchert............................p. 271
(See also Plates XL, XLI, and XLIII.)

Fig. 1. A large and characteristic specimen of this species; holotype, 35,085.

Fig. 2. Another large and old specimen in which the lower half of the bulb is covered with a secondary deposit of calcareous matter through which pass large and modified openings.

Fig. 3. A small specimen illustrated to show the four small lobations or camaræ situated on the right and left of the figure; this figure also shows how the root branches terminate in the camaræ walls. 35,085.

Fig. 4. A siliceous etched base of a medium-sized bulb, showing the medio-basal chamber surrounded by 5 camaræ, each of which has a large opening through the test. 35,084.

CAMAROCRINUS

EXPLANATION OF PLATE XLIII

(Untouched photograph.)

Camarocrinus ulrichi Schuchert.....................................p. 271

(See also PLATES XL–XLII.)

A slab 9¾ inches long, showing 4 specimens with the rounded end upward and 1 lying on its side; the photograph is of the upper side of the slab in situ. 35,085.

Helderbergian, 3 miles northeast of Daugherty, Indian Territory.

CAMAROCRINUS

EXPLANATION OF PLATE XLIV

(The illustrations on this plate are one-third smaller than the specimens.)

FIGS. 1-5. *Camarocrinus stellatus* Hall................................p. 269

Figs. 1–3. Three transverse cuts through the same bulb; the letters indicate the same wall in the different sections; ***M***, the medio-basal chamber.

Fig. 4. Another specimen cut through the center longitudinally; ***M***, medio-basal chamber.

Fig. 5. A second bulb cut through the center longitudinally. All 35,080.

Manlius formation, near Keyser, West Virginia.

CAMAROCRINUS

MODEL OF THE WAT CHANG PAGODA IN THE NATIONAL MUSEUM

THE WAT CHANG PAGODA OF BANGKOK, SIAM

By I. M. CASANOWICZ

The Wat Chang ("great monastery") pagoda, of which the United States National Museum possesses a model in wood, is considered the most magnificent one in Bangkok, the capital of Siam. It is an octagonal brick structure rising in three elegantly tapering stages upon a quadrangular platform, the whole conveying the idea of a gigantic bell (plate XLV). Staircases lead up from one stage to the other. Upon the last rests the dome, which, however, is more in the form of a cone or an octagonal prism with a rounded, dome-like top, than of a hemisphere, terminating in a metal tree-shaped spire. Four smaller domes, likewise surmounted by spires, surround the principal one. Underneath each of these are rectangular niches which formerly held images of Buddha. Rows of sculptured images of Buddhas and Bodhisattvas (candidates for Buddahood, or future Buddhas, and saints), seated on mythical animals, surround the octagon at various stages, and the whole building is lavishly adorned both in color and carving. Its outside plastering is wrought into a mosaic by means of porcelain of different colors set in it so as to form figures of elephants, griffins, demons, flowers, etc. It is assumed that the pagoda measures, from the base to the tip of the spire, about 250 feet in height. It is surrounded by an ornamental carved rail, at the four corners of which are small pagodas of a design similar to the central one, and in the niches are still seen the Buddha images riding elephants. In the center of each side is a kind of decorative gate, joining by platforms with the main pagoda, the whole thus constituting a cruciform plan. Inside the enclosure are dwellings for the monks in attendance on the sanctuary, flower and fruit gardens, ponds, grottos, and various stone images.

Pagodas[1] are religious structures which originated with Buddhism in India and are characteristic of Buddhist countries. Their original purpose was to receive the relics of Buddha, or the remains of such of his disciples as distinguished themselves by piety or learning. Thus, according to tradition, the remains of Buddha, after cremation of his body, were divided into eight portions and distributed among his followers, who erected pagodas over them, and legend makes

[1] The word *pagoda* is probably derived from the Singhalese *dagoba* or *dagaba;* in Sanskrit *stupa,* Pali *thupo,* whence Anglo-Indian *tope.*

King Asoka, the patron and propagator of Buddhism in the 3d century, B. C., build 84,000 stupas all over India in commemoration of the same number of discourses supposed to have been delivered by Buddha, or in honor of the number of atoms of which Buddha's body consisted. But already in the early periods of Buddhism stupas were constructed *ex voto* either for marking some important event in the life of Buddha and the history of Buddhism, or for decorating the monasteries and temples. At present pagodas are built chiefly as an act of devotion on the part of some pious person desirous of acquiring merit. In keeping with the original purpose of the pagoda, its earliest architectural style was derived from the tomb or tumulus. The earliest stupas are simple cupolas or hemispheres raised on a low basement, about half the diameter in height. With the exception of the small chamber for the ashes or relics, these shrines were solid masses of bricks or stone. One of the most important surviving structures of this kind is the Sanchi stupa, also known as the Bhilsa tope, in central India, which is a solid dome of stone, 106 feet in diameter and 46 feet in height, and which Cunningham would ascribe to the 3d century B. C. Gradually the plinth was increased until it rose from one to two diameters in height, of which the finest existing example is the great stupa of Dhamek at Sarnath, Benares, which was built about the 6th century A. D.[1]

The apex of the dome was usually surmounted by a disk placed horizontally, on which rose, as a terminal, an opened umbrella, the most common emblem of royalty and state among Eastern nations, or perhaps to symbolize the wandering mendicant monks of Buddhism. Ferguson[2] surmises that the umbrella, or *tee*, in its earliest form was, or at all events represented, a relic box, assuming that originally the relic was very likely not placed in the tope but on its top. Later the number of umbrellas was increased to 3, 7, 9, 11, and even 13 (always on odd number), placed one above the other.

In Tibet, and more especially in China, the terminal has frequently become the whole monument, the dome being wholly omitted. The most magnificent example of this style is the porcelain pagoda of Nankin, China, generally called the "Temple of Gratitude," which in its nine stories rises to a height of 236 feet.

The pyramidal shape observed in the Wat Chang pagoda is the most common for these religious edifices of Buddhism, and in this respect they recall the terraced Temple Towers in Babylonia, a model of which can also be seen in the National Museum.

[1] Compare A. Cunningham, *Mahabodhi, or the Great Buddhist Temple under the Bodhi Tree at Buddha-Gaya*, London, 1892, p. 47.

[2] *Handbook of Architecture*, London, 1859, p. 19.

DESCRIPTION OF A NEW *MYIARCHUS* FROM GRENADA AND ST. VINCENT, WEST INDIES

By J. H. RILEY

While examining a small series of *Myiarchus oberi* Lawrence in the United States National Museum, I was impressed by the differences between specimens from Grenada and St. Vincent on the one hand and Dominica and Santa Lucia on the other. As the type of *Myiarchus oberi* came from Dominica, the Grenada and St. Vincent form may be known as:

MYIARCHUS OBERI NUGATOR subsp. nov.

Type.—U. S. National Museum, No. 74,171, adult male, Grenada, W. I., March, 1878. Collected by F. A. Ober.

Subsp. characters.—Similar to *Myiarchus o. oberi*, but greater and middle wing-coverts and tertials broadly edged with white, and upper tail-coverts without rufous edgings.

Measurements of *Myiarchus oberi oberi*

Museum No.	Sex	Locality	Wing	Tail	Culmen	Tarsus	Middle toe
Type 77,828	♂	Dominica.	98	87.5	22	24	14.5
77,829	♀	Dominica.	96.5	87	22.5	25	14
90,618	—	Dominica.	102.5	94.5	23	—	—
80,898	—	Santa Lucia.	106.5	96	24	26	15

Measurements of *Myiarchus oberi nugator*

Museum No.	Sex	Locality	Wing	Tail	Culmen	Tarsus	Middle toe
74,072	♂	St. Vincent.	98.5	88.5	23	24.5	14.5
74,071	♀	St. Vincent.	100	93.5	23	25	14
Type 74,171	♂	Grenada.	100.5	90	24.5	25	15
84,846	♀	Grenada.	94	84	22.5	22.5	14
74,172	♀	Grenada.	92.5	85.5	23.5	24.5	14.5

Description.—Above olive, slightly darker on the head; remiges clove brown, the primaries (except the outer two) narrowly edged with rufous for about a third of their length from their bases, the secondaries narrowly and tertials broadly edged with white; wing-coverts same color as the back, with the greater and middle coverts rather broadly edged with white, forming two wing bars; middle tail feathers clove brown, the remaining tail feathers clove brown with broad cinnamon-rufous margins occupying nearly the whole inner web, except a narrow line parallel with the shaft; throat and jugulum lavender-gray; breast, abdomen, under tail-coverts, and under wing-coverts straw yellow.

Remarks.—The single specimen from Santa Lucia before me is larger than the type of *Myiarchus oberi* and the greater and middle coverts are slightly edged with wood brown, forming two obsolete wing bars, but it agrees better with *M. o. oberi* than with the present form. The St. Vincent specimens are not appreciably different from those from Grenada. For measurements see the table.

CATALOGUE OF A COLLECTION OF BIRDS FROM BARBUDA AND ANTIGUA, BRITISH WEST INDIES

By J. H. RILEY

This list is founded on a collection of three hundred and twenty-four bird skins, formed by Mr. H. G. Selwyn Branch on the islands of Barbuda and Antigua, British West Indies, during the late summer, fall, and early winter of 1903, and recently acquired by the United States National Museum. This collection is interesting as being the largest ever formed on these ornithologically little-known islands and for the fact that it contains a fine new species of *Dendroica* from Barbuda, the first peculiar species known from the island; some of the species are also recorded from the islands for the first time.

Antigua lies about thirty-eight miles north of Guadeloupe, and Barbuda about thirty miles north of Antigua, of which politically it is only a parish. Both islands belong to that outlying calcareous chain of islands that lies north and east of the volcanic chain of the Leeward islands. This outlying calcareous group consists, Mr. R. T. Hill states,[1] of the islands of Sombrero, Anguilla, St. Martins, St. Bartholomew, Barbuda, part of Antigua, the Grand Terre of Guadeloupe, and Marie Galante, and is of quite a different formation from the volcanic islands from Saba southward. They are said to be dry islands, with a comparatively sparse vegetation that seems to have had its effect on the bird life to a certain degree. This group of islands is also interesting as the meeting place of the Greater and Lesser Antillean faunas, for while some of the Greater Antillean species reach the islands from the north, they also mark the northern limit of a few of the Lesser Antillean forms.

Mr. F. A. Ober visited both Barbuda and Antigua in 1877, and a paper was prepared by Mr. Geo. N. Lawrence and published in volume I of the *Proceedings of the U. S. National Museum*. Forty-two species were recorded from Antigua and thirty-nine from Barbuda; only one species was described as new, *Speotyto amaura* from Antigua, a species not represented in the present collection. Mr. Cyrus S. Winch, one of Mr. C. B. Cory's collectors, visited Antigua in 1890, and a nominal list of thirty-two species was published in

[1] *Cuba, Porto Rico*, etc., 2nd ed., 1899, p. 318.

The Auk for 1891. Excepting a few scattered notices, the foregoing appears to be the only scientific bird collecting of which we have any record up to the time of Mr. Branch's visit to the islands.

Combining Lawrence's *List,* the additional species added in Cory's *Catalogue,* and the present list, we have a total now recorded from Barbuda of fifty-nine and from Antigua of sixty-one forms.

Family COLYMBIDÆ

1. PODILYMBUS PODICEPS (Linnæus)

One male, Barbuda, Sept. 26; one female, Antigua, July 24.

The black throat-patch appears to be more restricted and the bills smaller when compared with specimens from the United States.

Family PELECANIDÆ

2. PELECANUS OCCIDENTALIS (Linnæus)

One female, Antigua, July 7.

Family FREGATIDÆ

3. FREGATA AQUILA (Linnæus)

One male and one female, Barbuda, Aug. 25; one male, Antigua, July 7.

Family ARDEIDÆ

4. NYCTANASSA VIOLACEA (Linnæus)

One immature male and one adult female, Barbuda; two immature males and one immature female, Antigua.

5. BUTORIDES VIRESCENS MACULATA (Boddært)

Cancroma maculata Boddaert, Table Pl. Enl., 1783, 54 (founded on Pl. Enl. No. 912, Crabier tacheté de la Martinique).

Two females from Barbuda; one adult, and one immature male from Antigua.

Average Measurements of:	Wing	Tail	Culmen
Seven males from the Lesser Antilles	173	62.5	59.5
Four males from Porto Rico	166	61.5	57.5
Four males from Cuba	169.5	61	58
Twelve males from Florida	182	67.5	62
Five males from northeastern United States	184	68	62.5

Green herons from the West Indies, except the Bahamas, are smaller, have the crest more plumbeous, and the white edgings to the wing-coverts are less pronounced and not so tawny in color when compared with Florida specimens. Boddaert's name as given above seems to be the earliest applicable to this form.

6. FLORIDA CÆRULEA CÆRULESCENS (Latham)

[*Ardea*] *cærulescens* LATHAM, Index Ornith., II, 1790, 690 (Cayana).

Two males and one female, Barbuda; two males, two females, and an immature female, Antigua.

Little blue herons from the Greater and Lesser Antilles, Central America, and South America are much darker than specimens from Florida and farther north and evidently represent a good race. Specimens from Cuba seem to be intermediate, but nearer the southern than the northern form.

7. EGRETTA CANDIDISSIMA (Gmelin)

One male, Barbuda, Sept. 22.

FAMILY ANATIDÆ

8. DENDROCYGNA ARBOREA (Linnæus)

[*Anas*] *arborea* LINNÆUS, Sys. Nat., ed. 10, 1758, 128 (America septentrionali).

One male, Barbuda, Nov. 16.

9. PŒCILONETTA BAHAMENSIS (Linnæus)

[*Anas*] *bahamensis* LINNÆUS, Sys. Nat., ed. 10, 1758, 124 (Bahama).

Two males and one female, Barbuda; one male and one female Antigua.

FAMILY NUMIDIDÆ

10. NUMIDA MELEAGRIS (Linnæus)

[*Phasianus*] *Meleagris* LINNÆUS, Sys. Nat., ed. 10, 1758, 158 (Africa).

Two males and two females, Barbuda, where they were introduced.

FAMILY RALLIDÆ

11. FULICA CARIBÆA Ridgway

Fulica caribæa RIDGWAY, Proc. U. S. Nat. Mus., VII, 1884, 358 (Guadeloupe and St. John's; type in U. S. Nat. Mus. from St. John's).

Two males and one female, Barbuda; three females, Antigua, agree with the type of this species. The two males measure: wing, 189–184 (186.5); tail, 51–50 (50.5); exposed culmen, 54–49 (51.5); the four females: wing, 192–169 (180.9); tail, 51–46 (49.4); exposed culmen, 50.5–43.5 (47).

12. GALLINULA GALEATA (Lichtenstein)

One male and one female, Barbuda; two males and one female Antigua.

FAMILY LARIDÆ

13. LARUS ATRICILLA Linnæus

Two females, Barbuda, Aug. 17 and Sept. 26.

14. STERNA MAXIMA Boddært

One female, Barbuda, Nov. 21.

15. STERNA HIRUNDO Linnæus

One female, Barbuda, Sept. 24.

16. STERNA ANTILLARUM (Lesson)

One male, Antigua, Aug. 10.

17. STERNA FULIGINOSA Gmelin

One male, and one without sex, Antigua.

FAMILY SCOLOPACIDÆ

18. ACTODROMAS MACULATA (Vieillot)

One male, Barbuda, Sept. 22.

19. ACTODROMAS FUSCICOLLIS (Vieillot)

Two females, Barbuda, Sept. 20 and 22.

20. EREUNETES PUSILLUS (Linnæus)

One male and one female, Barbuda, Sept. 22.

21. NUMENIUS HUDSONICUS (Latham)

Two females, Barbuda, Sept. 25 and Nov. 12.

FAMILY CHARADRIIDÆ

22. CHARADRIUS DOMINICUS Müller

One male, Barbuda, Sept. 2.

FAMILY COLUMBIDÆ

23. COLUMBA SQUAMOSA Bonnaterre

One male, Antigua, Oct. 2.

24. COLUMBA LEUCOCEPHALA Linnæus

Two adult and two immature females, Barbuda; one adult and one immature male, one adult and one immature female, Antigua.

The immature males and female are almost in full adult plumage, except the top of the head which is washed with brown.

25. ZENAIDA ZENAIDA AURITA (Temminck)

Columba aurita TEMMINCK, Pigeons, I, fam. sec., 1808–11, 60, pls. 25 (ad.), 25 *bis* (yg?). (Martinica.)

Three males and four females, Barbuda; four males and three females, Antigua; one specimen without label.

This series shows a remarkable variation without respect to sex or locality. There are three types of coloration, as follows: (1) with the belly and under tail-coverts whitish; (2) with the belly and under tail-coverts vinaceous; and (3) with the belly and lower tail-coverts light gray. Some of the specimens with the belly and lower tail-coverts vinaceous approach *Zenaida zenaida* but are never quite so dark. In fact they are intermediates, as already pointed out by Mr. Cory (Cat. Bds. Brit. Mus., XXI, 1893, 383). Temminck's plate of the adult shows the gray style of coloration.

26. COLUMBIGALLINA PASSERINA TROCHILA Bonaparte

Ch[*amæpelia*] *trochila* BONAPARTE, Consp. Av. II, 1854, 77 (Martinica).

Two males and four females, Barbuda; three males and five females, Antigua.

The ground doves of the West Indies are in great need of revision. Almost every island or group of islands presents more or less well-marked differences when compared. Antigua and Barbuda specimens appear to have more rufous on the primaries with narrower black edgings and to be slightly darker than specimens from the other Lesser Antilles available for comparison; the latter character is probably due to the freshness of the specimens. I have no specimens from Martinique suitable for comparison and therefore use Bonaparte's name provisionally for the form inhabiting the Lesser Antilles. I give the average measurements of the series of ground doves in the U. S. National Museum from the Lesser Antilles for comparison.

AVERAGE MEASUREMENTS OF:	WING	TAIL	CULMEN
Three males from Antigua	82.5	57.3	10.7
Five females from Antigua	81.7	59.4	10.6
Three males from Barbuda	78.3	58.5	10.5

Average Measurements of:	Wing	Tail	Culmen
Four females from Barbuda	81.9	55.9	11[1]
One male from St. Bartholomew.	81	60	......
One male from St. Kitts..	82	66.5	11
One male from St. Eustatius	82	61.5	11
One female from St. Eustatius.	78.5	57.5	10.5
Two males from Guadeloupe	82.5	58.5	11
One male from Dominica	83	59.5	11
One female from Dominica	84	61.5	11
One male from St. Vincent	81.5	53.5	11.5
One female from St. Vincent	80	54	11.5
One male from Grenada..	78	55	11.5
One female from Grenada	77.5	57	12

Family BUTEONIDÆ

27. BUTEO PLATYPTERUS Vieillot

Three immature females, Antigua.

All three specimens are very light colored (especially two of them), the lightest colored of which has the feathers of the head and hind neck white with a broad pear-shaped shaft streak of dark brown, making it appear streaked in about equal proportions of white and brown; the scapulars and greater wing-coverts contain a great amount of white; the primaries and tail are white at their bases; the brown streaks below are small and mostly confined to the cheeks and side of neck, barely meeting across the jugulum.

I can find no specimen in the U. S. National Museum to match these specimens, and they may represent an undescribed form. Mr. Cory (*Auk,* 1891, 47) has also remarked on the light colors of Antiguan specimens.

Family FALCONIDÆ

28. CERCHNEIS SPARVERIA CARIBÆARUM (Gmelin)

[*Falco*] *caribæarum* Gmelin, Sys. Nat., I, part I, 1788, 284.

Two males and four females, Barbuda; two males and three females, Antigua.

Gmelin's name as quoted above was founded primarily on Brisson's *Aesalon Antillarum,* that, judging from the description, came from one of the Lesser Antilles, probably one of the islands then under French rule. As quite a different form has usually been described under Gmelin's name, I give a description for comparison.

Adult male.—No. 191,134, U. S. N. M.; Barbuda, B. W. I., Aug. 21, 1903; collected by H. G. Selwyn Branch.

Top of head slaty gray, enclosing a large patch of cinnamon-rufous, the whole top of head with narrow black shaft-streaks; back, scapulars, and tertials cinnamon-rufous barred rather heavily with

[1] Three specimens.

black; rump rufous; tail, except outer feather, dark rufous with interrupted bars of black, a broad subterminal black bar, the tip rufous; the outer tail-feather buffy white at the base and on the outer web, rest rufous with only a narrow black shaft-streak, the subterminal black bar reaching little beyond the shaft; forehead, superciliary streak, cheeks, throat, breast, and under tail-coverts buffy white; upper breast with narrow black streaks, lower breast and flanks with oval black spots; an ochraceous-buff collar on hind part of neck; rictal stripe, stripe on side of neck, a spot a little lower down, and another on occiput black; primaries black, narrowly tipped with buff, the inner web with large white spots in a sawtooth pattern, edged with rufous; secondaries black, tipped with slaty and buff, the inner web of the feathers with large white spots, the inner feathers with some slaty and rufous bars and spots; primary coverts black barred with slaty and rufous; lesser coverts slate gray, the feathers tipped and barred near the base with rufous and black, the subterminal bar on some of the feathers being contracted into a cordate spot; under wing-coverts buff. Wing, 169; tail, 121; culmen, 12.5.

Variations in the males.—The series before me from the various islands south of the Anegada channel shows considerable variation within certain limits. In some the black bars on the tail do not reach the shaft, while in others they are complete; the rumps on some are spotted with black; the lesser wing-coverts are not tipped with rufous, and the black spots are more pronounced in some than others; the rufous spots on the head in two specimens (Nos. 77,844, Dominica; 96,481, Guadeloupe) is very extensive, occupying nearly the whole top of head, and are without the narrow black shaft-streaks; the buffy collar is absent in nearly all the specimens except the one described; in about half the specimens the tip of the tail is white; in most of the series the breast is more or less tinged with ochraceous-buff; the under wing-coverts are sometimes spotted sparsely with black; the outer tail-feather in some specimens is white barred with black, and between this condition and the one described there is almost every variation with hardly two exactly alike.

Females.—The females differ from the males in being lighter in color; more heavily barred above; the rufous spot on the head not so pronounced and the shaft-streaks more numerous and heavier; the black bars on the tail are heavier, except the subterminal bar which is not so wide, and the bars are never broken; the lesser coverts of the wing are rufous barred with black, not slaty; the spots on the underparts are more numerous and streaky.

Habitat.—This form probably inhabits most of the Lesser Antilles from the Anegada channel southward. Specimens from Porto Rico and probably eastward to the Anegada channel belong to a different form that is apparently without a name. It may be known as:

CERCHNEIS SPARVERIA LOQUACULA new subsp.

Type No. 169,029, U. S. N. M., ♂ ad., Isabel II, Vieques island, Porto Rico, Feb. 8, 1899. Collected by A. B. Baker.

Similar to *C. s. caribæarum* but with the breast deep vinaceous-cinnamon, the back darker, the tail and back less heavily barred, and the under wing-coverts always spotted with black. Wing, 172; tail, 124.5; culmen, 13.

Females similar to females of *C. s. caribæarum* but darker above with the rufous spot on head much more pronounced; below with the spots and streaks more numerous and heavier, and with a strong suffusion of vinaceous-cinnamon.

MEASUREMENTS OF *C. s. caribæarum*

	WING	TAIL	CULMEN
Two males, Barbuda	172.7	125	12.5
Four females, Barbuda	177.4	126.5	13.2
Three males, Antigua	167.2	120.8	13.2
Three females, Antigua	178.8	124.2	13[1]
One male, St. Bartholomew	174.5	123	13.5
Two females, St. Bartholomew	174.5	124.2	13.2
One male, St. Eustatius	170.5	121	12.5
One male, Nevis	166.5	118.5	12
One male, Saba	167	120	12.5
One male, St. Kitts	173.5	124.5	12
One female, St. Kitts	175.5	119	13
Two males, Guadeloupe	169.5[2]	116	13.2
Two females, Guadeloupe	176.2	125	14
One male, Dominica	168.5	125	13

MEASUREMENTS OF *C. s. loquacula*

	WING	TAIL	CULMEN
Nine males from Porto Rico, Culebra, and Vieques	167	121.2	13.2[3]
Six females from Porto Rico and Culebra	179.2	128.6	13.8
Two males from St. Thomas	167.5	123	13
Two females from St. Thomas	179	130.2	14
One male from Anegada	174	122.5	......
One female from Anegada	179	135	13

[1] Two specimens. [2] One specimen. [3] Eight specimens.

FAMILY CUCULIDÆ

29. COCCYZUS MINOR NESIOTES (Cabanis and Heine)

C[occygus] nesiotes CABANIS and HEINE, Mus. Heineanum, part IV, heft I, 1862–63, 78, foot-note (Greater Antilles, in summer wandering to Florida).

Three males and two females, Barbuda; two males and seven females, Antigua.

In identifying this series I have gone over all the specimens from the West Indies in the collection of the U. S. National Museum and am prepared to recognize three forms as was done by Shelley in Cat. Bds. Brit. Mus., vol. XIX, 1891, but with quite different limitations. The three forms I am prepared to recognize are as follows:

1. *Coccyzus minor maynardi* RIDGWAY

From the Bahamas and southern Florida.

Characterized by its pale coloration.

2. *Coccyzus minor nesiotes* (CABANIS AND HEINE)

From Haiti, Jamaica, Grand Cayman, Mona, Porto Rico, Vieques, St. Thomas, Antigua, and Barbuda, West Indies, and Swan island, off coast of Honduras. This race is much paler on the throat and has the underparts paler than a specimen of *Coccyzus minor* from Colombia (the type locality of *minor* is Cayenne), the only specimen from South America available for comparison. Our specimens from Haiti, Grand Cayman, and Mona average paler than the rest of the series, but in the case of the Mona specimens I think this is due to the season (late summer) in which they were collected. The two specimens from Haiti approach *C. m. maynardi* but are more buffy on the cheeks and are referred provisionally to this form. *C. m. nesiotes* has a smaller and weaker bill than the next.

3. *Coccyzus minor shelleyi* nom. nov.

Shelley described this form as *Coccyzus dominicæ* (Cat. Bds. Brit. Mus., XIX, 1891, 306) from Dominica, but unfortunately Linnæus named the resident West Indian form of *Coccyzus americanus*, *Cuculus dominicus* (Sys. Nat. 1766, 170), which makes it necessary to rename this form. I have accordingly given it the name of the describer.

The present form has a larger, thicker bill than *C. minor* or *C. m. nesiotes*. It is also darker than the latter. The U. S. National Museum collection contains specimens of this form from Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, and Grenada. One of the specimens from Guadeloupe has a very short, thick bill, that is probably due to individual variation or to immaturity, as it is a young bird, though fully grown.

MEASUREMENTS OF *C. m. maynardi*

	Wing	Tail	Culmen	Depth of Bill
3 males from the Bahamas	131.5	161.7	27.3	9.2
3 females from the Bahamas	133.8	156.5	28.2	10

MEASUREMENTS OF *C. m. nesiotes*

	Wing	Tail	Culmen	Depth of Bill
1 male from Haiti	128.5	147	26.5	9
1 female from Haiti	129.5	158	26.5	10
1 female from Grand Cayman	135.5	162	28	10
1 female from Jamaica	138	166.5	26	9
2 males from Mona	126	159.2	29	9
4 females from Mona	130.9	154.9	27.1	8.9
1 female, Vieques, and 3 females, Porto Rico	131.7	164.7	26.2	9.8
1 female and 3 unsexed, St. Thomas	129	162.4	26.2	8.8
4 males, Antigua	135.2	162.7	28	9.6
7 females, Antigua	140.8	161.4	27.9	10.1
3 males, Barbuda	146.8	164.8	27.7	10
2 females, Barbuda	146.5	168.5	29	10
1 male, Swan island	135	170.5	29	10
1 female, Swan island	140	177	27	9.5

MEASUREMENTS OF *C. m. shelleyi*

	Wing	Tail	Culmen	Depth of Bill
1 male, Guadeloupe	144	171	28.5	10.5
1 male, Dominiça	144	161	28.5	11.5
1 female, Dominica	137	174	28.5	11
1 male, Martinique	141	169.5	31.5	11.5
1 female, Martinique.	151.5	194.5	30.5	11
1 unsexed, St. Lucia	143.2	169	29	11.2
1 male, Grenada	136	063	30	11.5

FAMILY ALCEDINIDÆ

30. CERYLE ALCYON (Linnæus)

One male and one female, Barbuda, Aug. 17 and Nov. 19; one male, Antigua, Oct. 23.

FAMILY TROCHILIDÆ

31. MICROLYSSA[1] EXILIS (Gmelin)

[*Trochilus*] *exilis* GMELIN, Sys. Nat., I, part I, 1788, 484 (Gujana).

One male and one female, Barbuda; four males and one female, Antigua.

32. SERICOTES HOLOSERICEUS (Linnæus)

[*Trochilus*] *holosericeus* LINNÆUS, Sys. Nat., ed. 10, 1758, 120 (America).

Five males and two females, Barbuda; four males and one female, Antigua.

FAMILY TYRANNIDÆ

33. TYRANNUS DOMINICENSIS ROSTRATUS (Sclater)

Tyrannus rostratus SCLATER, Ibis, Jan., 1864, 87 (Ins. Trinidad et in Guiana).

Four males and two females, Barbuda; seven males and three females, Antigua.

This series averages a clear gray, with the concealed crown-patch brighter, than in a series from Guadeloupe southward, but this is probably due to the freshness of the specimens and to the fact that the crown-patch has just been or is being assumed. The bill is slightly smaller and more pointed at the tip in Barbuda and Antigua specimens. In the collection there is a specimen, from Eleuthera island, Bahamas, of *T. dominicensis* hardly distinguishable from *T. rostratus* and is either a stray or an intermediate; at any rate *T. rostratus* is hardly entitled to specific rank.

Five males from Dominica southward (Guadeloupe specimens unsexed and not measured) average: wing, 119.2; tail, 94.4; culmen, 30.5.

Ten males from Barbuda and Antigua, average: wing, 117; tail, 93.4; culmen, 29.2.

34. MYIARCHUS BERLEPSCHII Cory

Myiarchus berlepschii CORY, Auk, July, 1888, 266 (St. Kitts, W. I.).

Eight males and one female taken on Barbuda, Aug. 29 and 30, and from Nov. 13 to 17, agree fairly well with a specimen from St. Kitts, except the upper tail-coverts in the Barbuda specimens are strongly tinged with rufous and the yellow below appears to be deeper; the latter probably due to the freshness of the specimens. The single female measures: wing, 89.5; tail, 79; culmen, 21.

A female from St. Kitts (the only specimen of *M. berlepschii* available) measures: wing, 88; tail, 78; culmen, 20.5.

[1] For the use of this name see *Auk*, Oct., 1904, p. 485.

The eight males from Barbuda average: wing, 92.6; tail, 81.7; culmen, 21.2.

35. ELÆNIA FLAVOGASTRA MARTINICA Linnæus

[*Musicapa*] *martinica* LINNÆUS, Sys. Nat., ed. 12, 1766, 325 (Martinica).

Six males, one female, and one unsexed, Barbuda; five males and five females, Antigua.

A series of this species from Grand Cayman southward to Guadeloupe appears to be paler both above and below than specimens from Guadeloupe south (except Barbados), until Grenada is reached, where true *flavogastra* apparently occurs.

FAMILY MIMIDÆ

36. MARGAROPS FUSCATUS (Vieillot)

Turdus fuscatus VIEILLOT, Ois. Am. Sept., II, 1807, 1 (Greater Antilles, particularly Porto Rico and St. Domingo).

Three males and two females, Barbuda; three males and one female, Antigua.

37. ALLENIA ALBIVENTRIS (Lawrence)

Margarops albiventris LAWRENCE, Ann. New York Acad. Sci., IV, 1887, 23 (Grenada).

One male and two females, Barbuda; three males and one female, Antigua.

The above series, when compared with a series from the other Lesser Antilles, averages more olive brown above, without the reddish cast in the plumage seen in the other series before me. The measurements are also slightly larger, as the following will show: Four males from Barbuda and Antigua average: wing, 129; tail, 104.6; culmen, 20. Seven males from Saba south to St. Vincent average: wing, 121.3; tail, 95.6; culmen, 19.4.

Lafresnaye's name of *Turdus montanus* (Rev. Zool., May, 1844, 167), generally used for this species, is preoccupied by *Turdus montanus* Voigt, Thierreich, I, 1831, 484; Audubon, Orn. Biog., IV, 1838, 487; and Townsend, Journ. Acad. Nat. Sci. Phila., 1839, 153. Lawrence's *Margarops albiventris* as quoted above appears to be the next available name given to the species.

FAMILY VIREONIDÆ

38. VIREOSYLVA CALIDRIS BARBADENSIS Ridgway

[*Vireosylva calidris*] var. *barbadense* RIDGWAY, in Baird, Brewer, and Ridgway, Hist. N. A. Bds., I, 1874, 359 (Barbados).

Four males and one female, Barbuda; five males, two females, and one unsexed, Antigua.

FAMILY MNIOTILTIDÆ

39. SETOPHAGA RUTICILLA (Linnæus)

Three males and four females, Barbuda, Aug. 10–Nov. 23; three males and two females, Antigua, Oct. 22–Dec. 14.

40. SEIURUS NOVEBORACENSIS (Gmelin)

Three males and three females, Barbuda, Aug. 25–Nov. 19; six males and one female, Antigua, Oct. 15–Dec. 12.

41. SEIURUS MOTACILLA (Vieillot)

One male, Antigua, Sept. 19.

42. SEIURUS AUROCAPILLUS (Linnæus)

Four males and one female, Antigua, Oct. 9 and 23, and Nov. 27.

43. DENDROICA DISCOLOR (Vieillot)

One male and one female, Barbuda, Nov. 2 and 23; one male and one female, Antigua, Oct. 5–13.

44. DENDROICA SUBITA new species

Type No. 191,301, U. S. N. M., ♂ ad., Barbuda, W. I., Sept. 19, 1903. Collected by H. G. Selwyn Branch.

Description.—Top of head, sides of neck, rump, and upper tail-coverts mouse gray; interscapular region hair brown; wings black, the feathers narrowly edged with gray, the tips to the greater coverts forming an obsolete dusky wing bar; tail black, the three outer feathers narrowly edged with white and with a large oblique white spot occupying the first and second feather but not reaching the tip, this spot much reduced on the third; a broad yellow superciliary stripe, scarcely extending beyond eye; a yellow suborbital spot, this spot separated from the superciliary by a loral streak and from the throat by a rictal streak of dusky; forehead slightly tinged with yellow; malar region, chin, throat, chest, and breast lemon yellow; belly and under tail-coverts white; thighs dusky; lining of wing white, slightly tinged with yellow on the carpus. Measurement of type: wing, 50.5; tail, 45.5; culmen, 10.5; tarsus, 18.5; middle toe, 10.

Female similar to the male.

Remarks.—This very distinct species needs no comparison with any known form, but belongs to the same section as *Dendroica ade-*

laidæ and *Dendroica delicata* from which it differs in the entirely different color of the upper parts, the lack of the black edging to the superciliary stripe, the obsolete or in some specimens absent wing-bars, and the white spot on the outer tail-feather not reaching the tip.

There are four males, two females, and one immature in the collection, all from Barbuda, taken between Aug. 25 and Nov. 20. The four males average: wing, 51.7; tail, 45.6; culmen, 10.9; tarsus. 18.2; middle toe, 10.4. The two females average: wing, 54.5; tail, 45.2; culmen, 10.7; tarsus, 18; middle toe, 10.2.

The immature specimen is similar to the adult except that it is just acquiring the yellow of the breast and throat. The yellow starting on the lower throat branches out on the breast into two broad bands; the chin and upper throat are dusky with only a few scattering yellow feathers; the yellow superciliary stripe is indicated only by a spot above the eye; and the suborbital spot is absent.

45. DENDROICA PETECHIA BARTHOLEMICA Sundevall

[*Dendroica petechia*] a. *bartholemica* SUNDEVALL, Ofv. k. Vet.-Akad. Forh. Stockh., 1869, 607 (St. Bartholomew).

Three males and two females, Barbuda; five males and two females, Antigua.

This series when compared with a series from Porto Rico and Vieques shows the latter to belong to a different form. The Barbuda and Antigua birds differ in having the backs darker without dusky streaks; the chestnut on the head in fully adult birds darker and more pronounced; and in being less heavily streaked below. Three males from Barbuda average: wing, 64; tail, 48.8; culmen, 11.8. Four males from Antigua: wing, 61.6; tail, 48; culmen, 11.5.

Sundevall's name [*Dendroica petechia*] *b. cruciana* (Ofv. k. Vet.-Akad. Forh. Stockh., 1869, 608), founded on the St. Croix bird, is probably applicable to the bird from Porto Rico and the Virgin Island group which should be known as *Dendroica petechia cruciana* Sundevall.

46. MNIOTILTA VARIA (Linnæus)

One male and one female, Barbuda, Nov. 17 and 23; two males and three females, Antigua, Oct. 5–Dec. 15.

FAMILY CŒREBIDÆ

47. CŒREBA DOMINICANA (Taylor)

Certhiola dominicana TAYLOR, Ibis, Apr., 1864, 167 (Dominica).

Five males, Barbuda; eight males and six females, Antigua.

This series averages more slaty black above, and clearer, brighter yellow below when compared with specimens from Dominica, probable due to the freshness of the specimens.

FAMILY TANAGRIDÆ

48. EUPHONIA FLAVIFRONS (Sparrman)

Emberiza flavifrons SPARRMANN, Mus. Carls., IV, 1789, no. 92.

One male, Barbuda; one male, Antigua.

FAMILY FRINGILLIDÆ

49. PYRRHULAGRA NOCTIS CORYI (Ridgway)

Pyrrhulagra coryi RIDGWAY, Auk, XV, Oct., 1898, 323 (St. Eustatius).

One adult and two immature males, one female, and one unsexed, Barbuda.

The adult male is in somewhat worn plumage. It agrees in color with the type of *P. coryi*, but the measurements are slightly smaller, probably caused by abraded plumage, except in the case of the bill. The type of *P. coryi* measures: wing, 68.5; tail, 51.5; culmen, 13.5. Adult male from Barbuda: wing, 66; tail 51.5; culmen, 12.

50. PYRRHULAGRA NOCTIS RIDGWAYI Cory

Pyrrhulagra noctis ridgwayi CORY, Cat. W. I. Bds., 1892, 150 (Antigua).

Seven males and two females, Antigua.

Five adult males average: wing, 68.2; tail, 50.1; culmen, 12.6.[1]

51. TIARIS BICOLOR OMISSA (Jardine)

Tiaris omissa JARDINE, 1847, 332 (Tobago).

Four males, Barbuda; three males, Antigua.

[1] Four specimens.

A NEW SPECIES OF *AMPHIDROMUS*

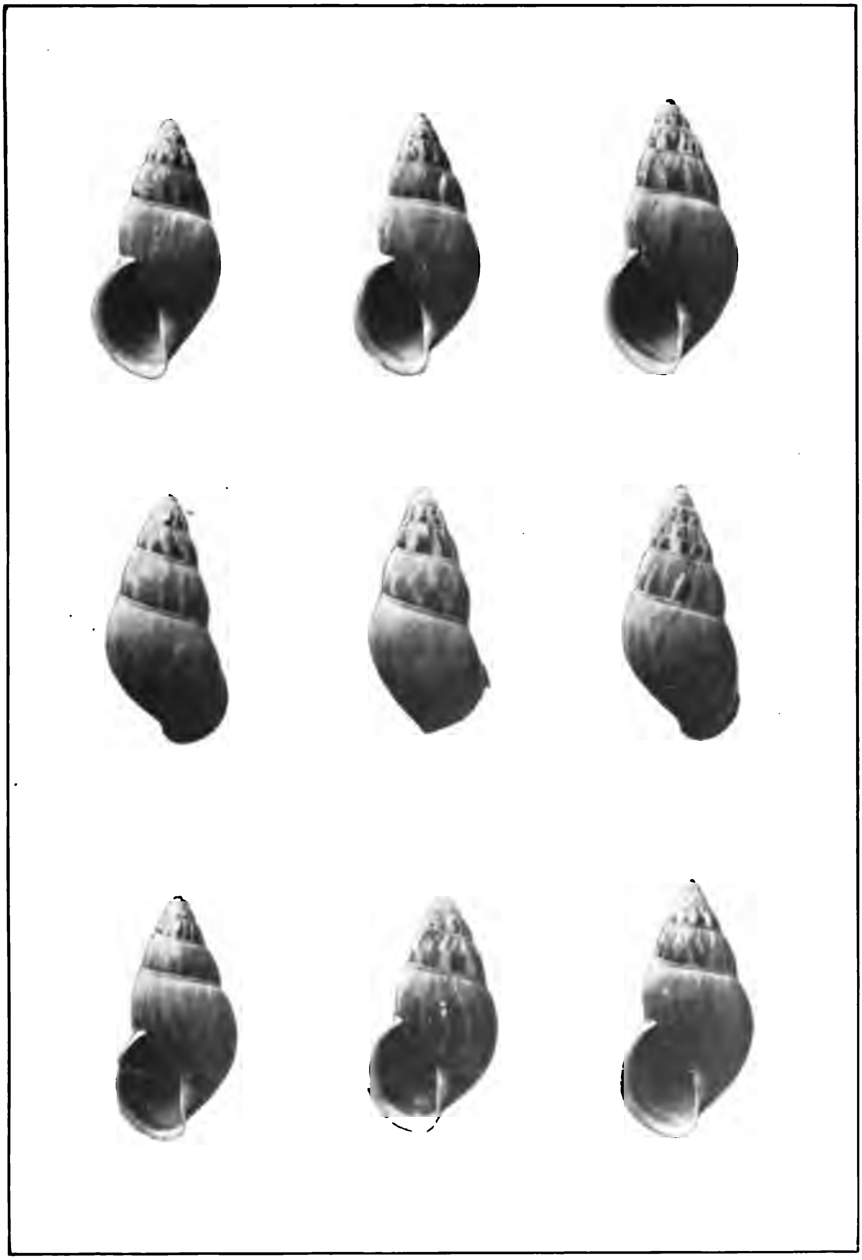
By PAUL BARTSCH

The United States National Museum recently received nine specimens of an undescribed species of *Amphidromus* (No. 177,911), from Mr. G. A. Goss, Waterbury, Conn. The specimens were collected by Messrs. Goss and A. D. Dodge on their recent trip to Mount Kin Baloo, North Borneo, at an altitude of 13,000 feet. The species is named in honor of the donor.

AMPHIDROMUS GOSSI new species

Specific diagnosis.—Shell sinistral, ovate-conic, imperforate, early whorls flesh-color with a brown tip, later whorls green with yellow axial stripes; aperture, outer lip, columella, and umbilical region rose-purple.

Description of the type.—Nuclear whorls one and three-fourths, well rounded, the first half volution dark chestnut-brown, smooth, the rest flesh-colored, showing, when viewed under high magnification, weak incremental lines and many somewhat triangular papillæ the apices of which point forward. Post-nuclear whorls four, polished, marked only by incremental lines and exceedingly fine microscopic spiral striations. The coloration is quite complex; the first two volutions are encircled by a moderately broad, pale greenish-yellow band at the summit and another between the sutures a little anterior to the middle; in addition to these there are irregular, alternating, axial stripes of greenish-yellow and light chestnut-brown, the first fusing with the spiral bands while the latter are interrupted and enclosed by them. On the third whorl the middle spiral band disappears, the yellow coloration becomes more intense (canary yellow), and the brown of the previous whorls gives place to a pale bice green; on this whorl the yellow axial stripes fork, or split up, on the posterior half between the sutures, the divisions fusing with the narrow spiral band at the summit. The last whorl is marked by irregular yellow and green axial stripes, the green being one and a half times to twice as broad as the yellow; the yellow axial stripes terminate about half way between the periphery and the umbilical region, leaving a plain green band, which is edged anteriorly by a narrow yellow spiral zone which separates the green from the purple-colored umbilical region. Aperture moderately large, dark rose-



AMPHIDROMUS GOSSI BARTSCH

purple within, outer lip thin, showing the external color markings by transmitted light, and having a quite strong, moderately expanded, and reflected rose-purple colored peristome; columella slightly curved and twisted, rose-purple, which is also the color of the umbilical region. On the parietal wall within the aperture a moderately broad yellow spiral band may be seen marking the termination of the axial yellow stripes on the penultimate whorl; in the type and six of the nine specimens this does not extend to the outer lip; in two of them, however, it extends somewhat beyond it. The type measures: alt. 32 mm., lat. 16.2 mm.; aperture alt. 15.5 mm., lat. 8.8 mm.

The deviations from the type consist chiefly in the number and size of the alternating axial color stripes and the degree of branching of these stripes on the posterior half between the sutures of the third whorl. The width of the yellow spiral band limiting the purple umbilical area is also somewhat variable; its greatest development appears to be on those specimens having the brightest and broadest yellow axial stripes. On two of the specimens the median spiral yellow zone between the sutures extends over one additional whorl, i. e., over the first three post-nuclear whorls. One specimen shows two very irregular and variously interrupted sooty spiral bands on the last whorl—one near the summit, the other near the suture, as shown in the middle figure of the top line, plate XLVI. The left figure on the bottom line represents the type.

A NEW SPECIES OF LIZARD FROM THE RIUKIU ARCHIPELAGO, JAPAN

By LEONHARD STEJNEGER

Among a large number of reptiles from Japan and the adjacent islands recently acquired by the United States National Museum from Mr. Alan Owston, there is a surprisingly distinct species belonging to the lacertine genus *Takydromus,* surprisingly distinct because the arrangement of the dorsal scales is entirely different from what is the universal rule in all the other species of the genus. There are about eight species known, and in all of these the dorsals are greatly enlarged and disposed in parallel longitudinal rows. In the new species the dorsals are small, not abruptly differentiated from the laterals and not disposed in longitudinal rows. With this character there are associated several others of great distinctness and importance.

TAKYDROMUS DORSALIS new species

Diagnosis.—Four pairs of submental shields; two inguinal pores on each side; dorsal scales small, not arranged in longitudinal series, gradually merging into the laterals which are rather large, not granular; six series of large ventrals, the outer series narrower than the others, median series very slightly keeled, if at all; posterior enlarged throat scales pointed; superciliaries separated from supraoculars by a series of granules; tail three times as long as head and body, or more; a light stripe from nostril to ear, but none on body.

Habitat.—Ishigaki shima, Yayeyama group, Riukiu archipelago, Japan.

Type.—United States National Museum No. 34,162; Ishigaki shima, Yayeyama group; April–June, 1899.

Variation.—In the ten specimens belonging to the National Museum but very little individual variation is observed. All have two inguinal pores on each side, except No. 34,163 which has three; all have four pairs of submentals; and all have the nasals in contact behind the rostral.

Remarks.—This exceedingly distinct species does not show any near affinity to any of the known species of the genus. It is absolutely unique in the arrangement and size of the dorsal scales.

Another unexpected character in so southern a species is the number of submental shields. Four submentals are found normally only in the northern forms such as *T. tachydromoides* and its allies.

The discovery of this novelty in the southern group of the Riukiu archipelago is the more startling, since we have *T. smaragdinus* from Miyako shima in the same group, a species which conforms in all respects to the general typus of the genus. On the other hand, the fact that we have ten specimens of the present species from Ishigaki shima and none of the regular type seems to indicate that the latter may not occur in that island at all.

NOTES

WATTS DE PEYSTER COLLECTION—NAPOLEON BUONAPARTE

The collection of books in the Smithsonian Institution known as the "Watts de Peyster Collection—Napoleon Buonaparte" was brought together by General John Watts de Peyster, of New York, a descendant of the distinguished family of that name which emigrated to this country early in the seventeenth century. General de Peyster was born in 1821, just after the time of the great Napoleon, and early in life commenced to accumulate a library of Napoleonic literature which has grown under his fostering care to a collection of books numbering in the thousands. Through his untiring efforts the world has been searched for books, pamphlets, maps, etc., relating to Napoleon Buonaparte or to the military celebrities and others connected with him.

In the latter part of 1901 General de Peyster offered to the Institution the collection, to be held intact and to be known by the name above given. General de Peyster estimated that there would be about two thousand titles, but considerably more than that number have been received, and there is promise that further search will reveal others in the libraries of General de Peyster's residences at Tivoli and New York City. At the time of sending the first part of the collection General de Peyster conservatively estimated its value at ten thousand dollars, but this estimate is evidently far below the real pecuniary worth of the collection, as many of the volumes have long been out of print and are now well-nigh priceless. As a historical collection the value of the library is beyond estimate.

The books, together with the pamphlets and maps, are cared for in twenty-four cases specially built for them and arranged along the north and south walls of the main hall of the eastern wing of the Smithsonian building. Each group of cases is provided with a conspicuous label giving the name of the collection. A number of busts of Napoleon and of others of his time, which General de Peyster collected in connection with the library, are to be placed on the tops of the cases as soon as proper mountings are prepared. A special bookplate is in preparation and as soon as engraved will be placed in each volume. It is hoped that ere long a complete card catalogue will be made and published, thus making this magnificent collection more fully accessible to students.

In addition to his Napoleon library, General de Peyster has presented a large number of histories of the American Revolution and the Civil War, dictionaries, encyclopedias, and other books of reference, together with numerous works on Gypsies, all of which he acquired during the prosecution of his various studies. Through his munificence, also, the historical collections of the Institution have been enriched by many objects relating to the Colonial period of America, including tableware, pistols, guns, pictures, etc.

General de Peyster has written numerous works on military and historical topics, and has contributed largely to periodical literature. Among his publications are *Waterloo: The Campaign and Battle; The Prussians in the Campaign of Waterloo; The Real Napoleon Buonaparte; Napoleone di Buonaparte; Marshall Blucher; Practical Strategy of the Austrian Field Marshall Traun; Life of Leonard Torstenson, Field-Marshal Generalissimo of Sweden; The Dutch at the North Pole and the Dutch in Maine; Carausius, the Dutch Augustus; Life of Lieutenant-General Menno, Baron Cohorn; Personal and Military History of Major-General Philip Kearny; The History of the Third Corps of the Army of the Potomac; The Decisive Conflicts of the Great American Civil War; The Last Campaign of the Army of the Potomac; The Ancient, Mediæval and Modern Netherlanders,* etc. General de Peyster's writings number perhaps hundreds of titles, and by American military experts he has been referred to as " the foremost military writer of the country."

The Smithsonian Alaska Expedition

In May of this year Mr. A. G. Maddren was authorized to undertake, in behalf of the Smithsonian Institution, an exploring expedition into Alaska, having for its immediate purpose the investigation of the numerous reported finds of remains of mastodon and other large mammals. Mr. Maddren left Seattle, Washington, May 24, and entered Alaska by way of Skagway and Dawson. From Dawson he proceeded down the Yukon to Eagle, thence to Circle City, stopping at the latter place long enough to investigate the reported remains on Mastodon creek. Thence he proceeded to Fort Yukon and up Porcupine river and its tributaries as far as Old Crow river, which latter stream was followed for a distance of one hundred and seventy-five miles; he then went down the Porcupine to Fort Gibbon, at the mouth of the Tanana. A severe epidemic of diphtheria among the Indians of Porcupine valley prevented him from obtaining the necessary assistance for a thorough exploration of the region, but evidence of the existence of an extensive deposit of vertebrate remains of various kinds was procured, and a small collection was brought away. It was Mr. Maddren's intention to proceed from Fort Gibbon down the Yukon some thirty-five miles to the locality known as the "bone yard," thence to Nulato and Kaltag, whence he would proceed overland to Nome by way of the Unalaklik, Ungalik, Unglutalik, and Tubatulik rivers. The reports thus far rendered, while not final (Mr. Maddren's last letter being dated August 5), encourage the hope of substantial results from another season's work.

The Smithsonian Glacier Expedition

The expedition dispatched by the Smithsonian Institution to the Canadian Rockies and Selkirks, under the immediate direction of Professor William H. Sherzer, of the Michigan State Normal School, has just closed an active and successful season's work on the glaciers along the line of the Canadian Pacific Railway. A selection was made of those five glaciers which are at the present time most readily accessible to the tourist, or the student of glacial geology, and these were found to exhibit, more or less strikingly, all the characteristic phenomena to be found in any part of the world. It may be a matter of surprise to many to learn that four or five days of comfortable railway travel places one in the midst of snow-fields rivaling in size and grandeur those of Switzerland, that the ice bodies descending from these fields may be studied from modern hotels as a base, and that, of those to be reported upon, one may safely ride a horse to the very nose of each. For trips on the ice to the passes and neighboring peaks, experienced Swiss guides are available during the summer months. So far as is known there is here the most magnificent development of glaciers of the Alpine type on the American continent, and the purpose of the survey was to gather as much information concerning them as the time and facilities rendered possible. Many photographs with which to illustrate the details of glacial structure were obtained, and it is hoped to place these, together with maps and descriptions, within the easy reach of all interested.

Field work began July 1st, with two assistants, and continued until the middle of September, camps being made at Lake Louise, Moraine Lake, and in Yoho, Asulkan, and Illecillewaet valleys, in each case as close as practicable to the glaciers under study. Quite in contrast with the two preceding summers, that of 1904 proved exceptionally propitious for field studies. The unusual number of bright days and the reduced precipitation, however, reacted unfavorably in that they permitted forest fires to spread in several of the valleys, and during much of the summer the atmosphere was more or less charged with smoke, rendering distant photography unsatisfactory or quite impossible.

Covered with a veneering of rock débris over its lower third, the Victoria glacier at Lake Louise is not the most interesting of the series to the casual observer, who is liable to carry home the idea that it is simply a stone heap, and a rather uninteresting pile at that. Geologically, however, this glacier is the most active and varied of any of those that can be conveniently reached in the entire region, and nearly six weeks were devoted to the study of it and its tributary, the Lefroy. In spite of the many visits which a camp alongside the glacier for this length of time permitted, as well as numerous visits during two previous seasons, not one failed to reveal some new feature or to shed important light on one previously observed. This longer stay at the Victoria permitted measurements of the forward flow of ice under variable conditions of temperature, the construction of an accurate cross-section, the determination of the amount of surface melting, and the varying amounts of drainage and sediment discharged—work which was not feasible on the other glaciers, to each of which but seven to ten days could be devoted. A detailed survey was made of each of the five glaciers, from the nose around each way to the nevé field, by means of plane-table or compass and steel tape, and full data for a map of the ice and moraines and for a general description were procured. Especial attention was given to the structure of the ice itself, with the hope of shedding more light on some of the points still under discussion.

Only the most general statements concerning those results of the field studies in which the scientific public may be interested will now be noted. The glaciers generally were found to be still in retreat, the Wapta, at the head of Yoho valley, having exceeded its average of the last three years by a few feet, while the Illecillewaet at Glacier House receded but one-third of the average which it has maintained during the last seventeen years. The Asulkan, in an adjoining valley, which had been advancing for about two years, has remained practically stationary during the last year. The Victoria presents an oblique front of nearly half a mile, and its lower eight hundred feet, completely veneered with rock as above stated, has pushed out into the forest at a comparatively recent date. This part has remained quiet apparently for a number of years, but accurate measurements to stones embedded in the face show that a very gradual wastage occurred during the summer, with a small stream of clear, ice-cold water as confirmatory evidence. Farther up, for a distance of about 1,600 feet, there is a steep ice front which is so nearly parallel with the main axis of the glacier that there is a question as to whether it is not its *side*. Here the front of the ice is receding, the amount for the last year being about the same as the average maintained for the last five or six years, and this in spite of an actual forward flowing movement of the ice of two to three inches daily in summer and perhaps half this amount in winter. The Wenckchemna glacier, in the Valley of the Ten Peaks, proved of exceptional interest because of its almost unique character, only one other of the type—the Malaspina in Alaska—having been described. The Wenckchemna consists of a sluggish ice mass, relatively short but broad, formed by the lateral coalescence of about a dozen short ice streams, each of which retains its identity more or less perfectly entirely across the glacier, and maintains its own nose and motion independently of its neighbors. Accurate measurements to stones embedded in the frontal slope showed that some of these ice streams are stationary, some receding, and others advancing, the most rapid advance being near the center, where freshly cut trees were observed. To those who do not fully appreciate all the factors of the problem it is frequently a matter of surprise that a glacier in one valley may be in retreat while that in an adjacent valley may be advancing, as has just been the case in the Asulkan and Illecillewaet valleys; but in the case of the Wenckchemna there is a still more varied behavior in streams that are actually side by side almost throughout their length.

RECENT PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST OF AUGUST, 1904, IN PUBLICATION NO. 1467

No.	*Title*	*Series*	*Price*
1478	Smithsonian Miscellaneous Collections (*Quarterly Issue*) vol. XLVII, Part 2 (containing Nos. 1479–1487)	M.C. XLVII	.50
1479	BRITTON, N. L. and ROSE, J. N. *Lenophyllum*, a new genus of Crassulaceæ (*Quarterly Issue*)..	M.C. XLVII	.20
1480	FEWKES, J. W. Porto Rican stone collars and tripointed idols (*Quarterly Issue*)..........	M.C. XLVII	.25
1481	BARTSCH, PAUL. Notes on the genus *Sonorella*, with descriptions of new species (*Quarterly Issue*)	M.C. XLVII	.25
1482	SCHUCHERT, CHARLES. On Siluric and Devonic Cystidea and Camarocrinus (*Quarterly Issue*)..	M.C. XLVII	.35
1483	CASANOWICZ, I. M. The Wat Chang pagoda of Bangkok, Siam (*Quarterly Issue*)..........	M.C. XLVII	.05

1484 RILEY, J. H. Description of a new *Myiarchus* from Grenada and St. Vincent, West Indies (*Quarterly Issue*)	M.C. XLVII	.05
1485 RILEY, J. H. Catalogue of a collection of birds from Barbuda and Antigua, British West Indies (*Quarterly Issue*)	M.C. XLVII	.10
1486 BARTSCH, PAUL. A new species of *Amphidromus* (*Quarterly Issue*)	M.C. XLVII	.05
1487 STEJNEGER, LEONHARD. A new species of lizard from the Riukiu archipelago, Japan	M.C. XLVII	.05
1488 Notes (including continuation of list of Smithsonian publications from August, 1904). (*Quarterly Issue*)	M.C. XLVII	.05

PUBLICATIONS IN PRESS

1489 Proceedings of Regents, Reports of Executive Committee, Acts of Congress, etc.	R. 1903
1490 SHALER, N. S. General description of the moon	R. 1903
1491 NICHOLAS, E. F. *and* HULL, G. F. The pressure due to radiation	R. 1903
1492 NORDMANN, CH. The sun-spot period and the variations of the mean annual temperature of the earth	R. 1903
1493 PERNTER, J. M. Methods of forecasting the weather	R. 1903
1494 BADEN-POWELL, B. Progress with air ships	R. 1903
1495 CHANUTE, O. Aerial navigation	R. 1903
1496 [BELL, A. G.] Graham Bell's tetrahedral kites	R. 1903
1497 CURIE, E. Radium	R. 1903
1498 THOMSON, J. J. Radium	R. 1903
1499 RAMSAY, WM. *and* SODDY, F. Experiments in radio-activity and the production of helium from radium	R. 1903
1500 ABBOT, C. G. The "N" rays of M. Blondlot	R. 1903
1501 LODGE, OLIVER. Modern views on matter	R. 1903
1502 CROOKES, WILLIAM. Modern views on matter: the realization of a dream	R. 1903
1503 CLARKE, F. W. The atomic theory	R. 1903
1504 LE BON, GUSTAVE. Intra-atomic energy	R. 1903
1505 WRIGHT, J. The electric furnace	R. 1903
1506 GIBSON, G. H. High-speed electric interurban railways	R. 1903
1507 GRADENWITZ, ALFRED. The Marienfelde-Zossen high-speed electric railway trials	R. 1903
1508 WATERHOUSE, J. The beginnings of photography	R. 1903
1509 LAPWORTH, CHARLES. The relations of geology	R. 1903
1510 CREAK, E. W. Terrestrial magnetism in its relation to geography	R. 1903
1511 BROOKS, A. H. An exploration to Mount McKinley	R. 1903
1512 PEARY, R. E. North polar exploration, 1898–1902	R. 1903
1513 MARKHAM, C. R. First year's work of National Antarctic expedition	R. 1903
1514 NORDENSKIÖLD, OTTO, *and others*. The Swedish Antarctic expedition	R. 1903

1515 COOK, O. F. Food plants of ancient America.................. R. 1903
1516 COVILLE, F. V. Desert plants as a source of drinking-water.... R. 1903
1517 DASTRE, A. A new theory of the origin of species............ R. 1903
1518 ANTHONY, M. The evolution of the human foot.............. R. 1903
1519 GILL, THEODORE. The name "Mammal" and the idea expressed. R. 1903
1520 VASCHIDE, N. *and* ROSSEAU, P. Experimental studies on the mental life of animals.................................. R. 1903
1521 COUPIN, HENRI. Animals that hunt.......................... R. 1903
1522 CHAPMAN, F. M. Flamingoes' nests.......................... R. 1903
1523 KIRKALDY, G. W. Upon maternal solicitude in Rhynchota and other nonsocial insects.................................. R. 1903
1524 FOREL, A. The psychical faculties of ants and some other insects .... R. 1903
1525 SCHIÖTT, JUL. Musk oxen in captivity....................... R. 1903
1526 HERZ, O. F. Frozen mammoth in Siberia..................... R. 1903
1527 RACOVITZA, E. C. Spouting and movements of whales.......... R. 1903
1528 SYMINGTON, JOHNSON. Problems arising from variations in the development of skull and brain............................ R. 1903
1529 MEYER, A. B. The antiquity of the lion in Greece............ R. 1903
1530 WIEDEMANN, A. The excavations at Abusir, Egypt........... R. 1903
1531 MESSERSCHMIDT, L. The ancient Hittites..................... R. 1903
1532 THOMAS, CYRUS. Central American hieroglyphic writing...... R. 1903
1533 HOLMES, W. H. Traces of aboriginal operations in an iron mine near Leslie, Mo... R. 1903
1534 TSYBIKOFF, G. TS. Lhasa and Central Tibet.................. R. 1903
1535 STEIN, M. A. A journey of geographical and archeological exploration in Chinese Turkestan............................ R. 1903
1536 NEUMANN, OSCAR. From the Somali Coast through Ethiopia to the Soudan.. R. 1903
1537 BRINKLEY, F. Primeval Japanese............................ R. 1903
1538 HULBERT, H. B. The Korean language....................... R. 1903
1539 BURR, W. H. The Republic of Panama...................... R. 1903
1540 NEWELL, F. H. The reclamation of the West................. R. 1903
1541 DURAND, W. J. Robert Henry Thurston...................... R. 1903
1542 REICH, EMIL. Theodore Mommsen........................... R. 1903

The following publications, included in the Classified List of Smithsonian Publications available for distribution April, 1904 (No. 1461), are now out of print:

Numbers: 47, 174, 334, 379, 383, 386, 584, 703, 704, 778, 779, 806, 820, 876, 881, 882, 906, 911, 919, 931, 932, 933, 934, 944, 1005, 1032, 1057, 1068, 1075, 1087, 1100, 1103, 1118, 1133, 1152, 1160, 1182, 1189, 1191, 1230, 1244, 1263, 1273, 1274, 1297, 1299, 1339.

THE SMITHSONIAN INSTITUTION

[illegible]

The National Museum

[illegible]

Bureau of American Ethnology

[illegible]

International Exchanges

[illegible]

Volume XLVII

Smithsonian Miscellaneous Collections

Volume II Quarterly Issue Part 1

SMITHSONIAN MISCELLANEOUS COLLECTIONS

QUARTERLY ISSUE

The Quarterly Issue of the SMITHSONIAN MISCELLANEOUS COLLECTIONS is designed chiefly to afford a medium for the early publication of the results of researches conducted by the Smithsonian Institution and its bureaus, and especially for the publication of reports of a preliminary nature. It is not designed that the Quarterly Issue shall supersede the regular series of the SMITHSONIAN MISCELLANEOUS COLLECTIONS, but, as its name implies, shall form a part thereof.

Following the long-established custom of the Institution, all contributions submitted for publication in the Quarterly Issue will be referred to a committee, on whose judgment of the value and correctness of such contributions the Institution will be guided.

The Quarterly Issue will be published about the first of January, April, July, and October. Each number will consist of about 144 pages and will be suitably illustrated.

CONTENTS

VOL. 47 1904

SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL. 2 QUARTERLY ISSUE PART 3

INQUIRY INTO THE POPULATION OF CHINA

By WILLIAM WOODVILLE ROCKHILL

I

From the earliest times of their history the Chinese have made, every few years, enumerations of the adult population of the Empire. The history of the census in China may be divided into two parts: during the first, extending from the first recorded count in the XXIII century B. C., down to 1712 A. D., with a few exceptions, the number of tax-paying households alone was recorded. In the second period the total number of individuals is purposed to have been taken.

In the first period the census was made solely for the purpose of levying the taxes, and there is every reason to believe that the local officials systematically kept the returns forwarded to the Central Government below the real figures, so as to divert to their own use as much of the taxes levied as they possibly could. In the second period, that reason no longer existing (see *infra* p. 307), it became a matter of pride with the officials, as well as good policy, to swell the returns of population.

There is much uncertainty as to the number of individuals contained in each recorded "household," or *hu*, and whether by the word "individual" (literally "mouth," *k'ou*) is to be understood *male adults*, or *both sexes*, or persons of all ages—exclusive of infants—who have never been included in the enumerations of any period. In the time of Mencius (IV century B. C.) the "family" (*chia*) was supposed to comprise eight months (*k'ou*). This was the number of persons whom 100 *mou* (about 15 acres) of medium land were computed to support.[1] Under some dynasties (as the Han) it would seem that the "household" comprised from 4.8 to 5.2 individuals; in others, the T'ang for example, it rose to 5.8. During

[1] Mencius, Bk. I, Pt. I, Ch. VII, 24.

others, as the Sung, it was only a fraction over two persons, according to Sacharoff,[1] though Biot[2] contends that in this period it was a fraction more than 5 persons, as in the preceding period of the T'ang. Under the Yuan dynasty, according to Amiot, the "household" comprised 5 persons, and in the succeeding Ming dynasty it seems to have varied from about 5 to over 6.6. Even during the present dynasty we are in grave doubt as to the numeric value of the term *hu* ("household," "family"). Father Amiot and other foreign writers have thought it represented 5 persons, de Guignes[3] says 2 to 3, but in the opinion of E. H. Parker it averaged 6 persons.[4] In the census of 1842, which gave the number of households and of individuals, the former averaged 2.3 persons to the family; and in a census of the city of Peking for 1846, it averaged 3.1. I am disposed to accept 4 as a fair figure for enumerations of the XVIII and XIX centuries.[5]

During the Han dynasty, from A. D. 1 to 156, we have ten enumerations,[6] the first, taken in A. D. 1, gave 12,233,062 "households" and 59,594,978 "individuals." The last, taken in 156, gave 16,070,906 "households" and only 50,066,856 "individuals." The territory over which these censuses extended did not vary appreciably during the whole of this period of 155 years; it was substantially the same as at the present day. The population during this century and a half was nearly stationary.

In A. D. 606, when China was again united under one rule, what has been held by western writers to be a very careful census was taken. It again gave the population of the Empire at about 55,500,000.[7]

During the VII, VIII and IX centuries, although a considerable number of enumerations of the people are recorded, they are so confused that it is impossible to fix with more than the roughest approximation the population, at that time, of China proper, which

[1] *Hist. Uebersicht der Bevölkerungs-Verhaltnisse China's*, p. 157.

[2] *Journal Asiatique*, 1836, tome I.

[3] *Voyage à Peking*, III, 69.

[4] See *infra*, pp. 307–308. In Japan the average number of persons by household, which often includes several families, was 5.55 at the close of 1898.

[5] It is true that, in the case of the prefecture of Wen-chou in Che-kiang, it was found in 1881 that the average number of persons per home was about 5.14 (see *infra*, p. 314), and in the case of Ch'ung-k'ing in Ssŭ-ch'uan in 1877 a detailed census of the city gave about 4.3 persons to a family (E. C. Baber, *Journ. of Explor. in West. China*, p. 25).

[6] Ma Tuan-lin, *Wen-hsien t'ung-k'ao*, Bk. 10.

[7] See Biot, op. cit., pp. 451–452.

then covered about the same area as at present. The census which appears to have been the most carefully made was that of the year 756. It gave 8,814,708 families and 52,919,309 individuals for the free population, exclusive of infants and very old people; it included the kingdom of Korea. The total population in A. D. 756 may therefore have been about 61,000,000. Biot, using the censuses referred to in this paragraph, has calculated the average yearly increase of the population of China proper between A. D. 650 and 755, and found it to have been about 0.0063 per cent.

During the XI century, when the empire was again united under the rule of the Sung, we have ten enumerations of the population, that of the year 1080 showing evidence of having been the most carefully taken. It gives the number of households of freeholders (*chu*) and tenants (*k'o*) as 14,852,686, or 33,303,889 individuals. No matter how numerous we allow the exempted and unenumerated classes to have been, it is not conceivable that they could have more than doubled this number; so we may, I think, safely assume that at the end of the XI century the population of China proper was not much more than 60,000,000, the same as in the middle of the VIII century.

Biot has calculated the average yearly increase during the Sung dynasty (A. D. 976 to 1102) and found that from 976 to 1021 it was about 0.02 per cent., and from 1021 to 1102 only 0.0103 per cent. or 0.015 per cent. during these 125 years.

In 1290, at the end of the Mongol conquest of China by Kublai Khan, a census of China proper gave 13,196,206 households of 58,834,711 individuals. Admitting that vast numbers of Chinese had been reduced to slavery by the Mongols and countless thousands had been killed, the population at the end of the XIII century can hardly have been much in excess of 75,000,000.

During the Ming dynasty there were no fewer than twenty-one censuses between 1381 and 1578. The highest figure of the recorded population during this period was 66,598,337 individuals in 1403, and the lowest 46,802,005 in 1506. The last census, that of 1578, taken at a time when the country was extremely prosperous and enjoying general peace, gave the population as 63,599,541 souls.

While agreeing with Sacharoff that the various censuses of this period are not of a trustworthy character, I believe they may be considered sufficiently accurate to show that during the XV and XVI centuries the population of China increased very slowly, certainly not more rapidly than during previous periods of its history.

The following returns of the detailed censuses of 1393, 1491, and

1578, are taken from the Annals of the Ming.[1] It must be noted that that of 1393 has no returns for several provinces of the Empire.[2]

	1393		1491		1578	
	Households	Individuals	Households	Individuals	Households	Individuals
Ssŭ-ch'uan	215,719	1,466,778	253,803	2,598,460	262,694	3,102,073
Kiang-hsi	1,553,923	8,982,482	1,363,629	6,549,800	1,341,005	5,859,026
Hu-kuang	775,851	4,702,660	504,870	3,781,714	541,310	4,398,785
Che-kiang	1,138,225	10,487,567	1,503,124	5,305,843	1,542,408	5,153,005
Fu-kien	815,527	3,916,806	506,039	3,106,060	515,307	1,738,709
Kuang-tung	675,599	3,007,932	467,390	1,817,384	530,712	5,040,655
Kuang-hsi	211,263	1,482,671	459,640	1,676,274	218,712	1,186,179
Shan-tung	753,894	5,255,876	770,555	6,759,675	1,372,206	5,664,099
Shan-hsi	595,444	4,072,127	575,249	4,360,476	596,097	5,319,359
Ho-nan	315,617	1,912,542	575,249	4,360,476	633,067	5,193,606
Shen-hsi	294,526	2,316,569	306,644	3,912,370	394,423	4,502,067
Yün-nan	59,576	259,270	15,950	125,955	135,560	1,476,692
Kuei-chou			43,367	258,693	43,405	290,972
Ching-shih			304,055	3,448,977	334,691	4,258,453
Nan-ching	1,912,914	10,755,948	1,511,853	7,993,519	2,069,067	10,415,861
	9,318,078	58,619,228	9,161,417	56,055,676	10,530,664	63,599,541

Between the founding of the present Manchu dynasty (A. D. 1644) and 1734, we have enumerations of the population by households for nearly every year. E. H. Parker has extracted them from the *Tung hua lu* for the years between 1651 and 1860.[3] From 1651 to 1730 they are as follows for every tenth year:

[1] *Ming Shih*, Bks. 40 and 43.

[2] It is interesting to note that nearly all European writers of the latter part of the XVI and of the XVII centuries, such as Trigault, Matteo Ricci, Herrada, Martin Martini, Semedo, Mandelslo, and Osbeck, give approximately the figure of the census of 1578 as that of the population of China in their time, some of them stating that it included only adult males, or "fighting men." I can find no authority for this in any Chinese work. Gemelli Careri (*Voy. Round the World*, Pt. IV, 326) made out the population of China at the end of the XVII century to be 59,788,364 men, "exclusive of women, children, paupers, officials, literati, army, the imperial clan, etc." He gives the number of families as 11,502,872. The figures, both of individuals and of households, are substantially those of the census of 1578. He cites no authority for his statement concerning classes of the population not included in the census. I am inclined to believe he took his figures and this statement bodily from Athanasius Kircher or Father Martin Martini, but they in turn furnish no authority for their belief that the recorded population was exclusively composed of male adults.

[3] E. H. Parker, *A Note on Some Statistics Regarding China*, Journal Royal Statistical Society, XII, Pt. I, pp. 150-156. Du Halde, *Description*, etc., II, p. 14, referring to the early enumerations of the present dynasty, states that the tax-payers were the adult males only between 20 and 60 years of age.

1651,	taxed	population	10,633,000	families.
1660,	"	"	19,088,000	"
1670,	"	"	19,396,000	"
1680,	"	"	17,095,000	"
1690,	"	"	20,364,000	"
1700,	"	"	20,411,000	"
1710,	"	"	23,311,000	"
1720,	"	"	24,720,000	"
1730,	"	"	25,480,000	"

In the case of the census of 1720 we are told that there were, exclusive of the taxed population, 309,545 families free from taxation; and 851,959 families in the case of that of 1730. Parker notes that "evidence clearly shows" (but as usual with him he does not go to the trouble of giving any) that the numbers given above must be multiplied by six, and not by five as was done by Amiot, in order to obtain the number of individuals." Pending production of evidence, I shall follow Father Amiot's views on this point, and would add 2 per cent. for the tax-free families, which include officials, literati, the army, etc. On this basis we find that the total population of China proper in 1651, during the troublous times which accompanied the establishment of Manchu supremacy, was about 55,000,000—just about the number we should have assumed it to be had we to deduct it from the data supplied by history alone. From 1651 down to the present time the figures of the returns vary with such extraordinary rapidity, so unlike anything we have noted in the whole long list of earlier Chinese enumerations, that one is inevitably brought to look on them as fanciful and probably far remote from the truth.[1]

In 1712 an imperial edict ordered that the number of families (24,621,334) given in the enumeration of the preceding year should remain the invariable basis for the assessment of the crown taxes, and that all subsequent censuses should give the total number of inhabitants. Nevertheless, it was only in 1741, after repeated orders had been given by the Imperial Government, that a return was made of the total population of China. According to it the population was 143,412,000. For 1743 we find in the Institutes of the Ta Ch'ing dynasty (*Ta Ch'ing Hui-tien*) a detailed census of the Seventeen Provinces—corresponding to the Eighteen of the present day, but again given by households. This census gave the total num-

[1] De Guignes (*Voyage à Peking*, III, 56–86), after a study of the Chinese census returns of 1743, 1761, and 1794, concluded that they were exaggerated, and also that the figure five adopted by the missionaries to ascertain the number of persons in a family was too high by half. He calculated the population of China proper in 1789 at 150,000,000 *as a maximum*.

ber of households (*hu*) as 28,877,364, comprising 143,621,460 individuals or about 4.8 persons to a household. To this number, which corresponds very closely with that given for 1741, Amiot would add 493,075 individuals for unenumerated officials, 2,470,000 for the literati, and 4,115,325 for the army. To this again he would add some 50,000,000 for the civil employés of government, the monks, nuns, brigands, vagabonds, troglodytes, etc., with which, he says, China is full. Here I think he is unequestionably wrong, for the civil employés were included either in the already accounted for class of officials, or in the general returns;[1] while as for monks, nuns, etc., the number was unquestionably so small that it may be omitted in such a rough estimate as that we are attempting to reach. We may adopt the number 143,000,000 individuals *as a maximum* for the total population of China proper in 1743.

The various estimates of the population made by the Government of China since 1743 are contained in the following table, in which have also been included the annual rates of increase or decrease between succeeding dates deducted from them:

Date.	Population.	Annual Increase.	Rate of Increase.
1743	150,700,000		
1749	177,089,000	4,398,167	2.90
1757	189,920,000	1,601,375	0.90
1761	200,339,000	2,604,750	1.37
1767	209,126,000	1,464,500	0.73
1771	213,897,000	1,192,750	0.57
1776	267,399,000	10,700,400	5.00
1780	276,632,000	2,308,250	0.86
1783	283,094,000	6,462,000	2.34
1812	360,444,000	2,667,241	0.94
1842	413,021,000	1,759,233	0.49
1850[2]	414,493,000	159,000	0.0384
1860	260,925,000	—15,356,800	—3.705 (decrease)
1882	381,309,000	5,472,000	2.097
1885[2]	377,636,000	— 1,224,333	—0.32 (decrease)

Since the last date in the preceding table a number of estimates of the population of China proper have been made by various writers, but none of the estimates has any particular value, all of

[1] *Ta Ch'ing Lü-li*, 3d Div., Bk. I, Sec. LXXVI, provides for the registration of persons in the civil and military services.

[2] The figures for 1850 and 1860 are given on the authority of the *Tung hua lu*. The data from which the figure for 1885 is deduced were supplied me in 1885 by the Chinese Board of Revenue (*Hu Pu*), and supplemented and completed by figures supplied by the same Board to Mr. Popoff for ten provinces for the year 1879. This enumeration, as also those for 1761, 1812, 1842, and 1882 are given in detail, *infra*, p. 321. See also S. Wells Williams, *The Middle Kingdom*, I, 258.

them being based on the data supplied Popoff for 1879 and 1882. E. H. Parker[1] gives from Russian sources the population of the various provinces for 1894; this is the wildest guess yet made, and foots up a total of 421,800,000. In 1903 the *Statesman's Year Book* (p. 506) published a table "issued by the Chinese Government as the results of a census taken for the purpose of the apportionment of the indemnity to the Powers," in which the population is estimated at 407,253,000. There is not a scintilla of evidence to show that any census was taken for the purpose stated, and furthermore there was no necessity for taking one, as the sums levied from the various provinces for the indemnity of 1900 were procured by indirect taxation. Here again we have nothing more than a guess of the Chinese Board of Revenue.

II

An attempt will now be made to determine the value of the various enumerations of population since that of 1741, which I am inclined to believe was probably a closer approximation to the truth than were any subsequent ones, the Imperial Government being in strong, intelligent hands, its mandates executed with more faithfulness and precision than at any other subsequent period, and the Empire enjoying perfect peace. I feel confident, however, that it was in excess of the truth, for it must be borne in mind that no census, such as we make in this country, has ever been attempted in China. The Statutes of the Empire[2] require, it is true, that all families should make returns of their members, and impose punishments for failure to comply or for falsification of returns; it would therefore seem easy to tabulate these returns at any time, but experience has proved that such is not the case. In China all statements of population are largely guess-work, and where numbers are guessed they are always magnified, especially when there is no reason to keep them down, as was the case prior to the Imperial Edict of 1712, referred to previously.

China enjoys a salubrious climate and a fertile soil, and the people have always been extraordinarily industrious and thrifty. As a general rule the taxation has been fairly equable, and life and property safe in times of peace. These conditions are all conducive to a large increase in population. There is another reason which should from the remotest times have been potent in producing a larger in-

[1] *China*, etc., 192.

[2] *Ta Ch'ing Lü-li*, 3d Div., Bk. I, Secs. LXXV, LXXVI.

crease of population in China than in other countries enjoying like natural advantages: I refer to the desire of every Chinese to have posterity, to keep up the ancestral worship. We find Mencius (B. C. 372–289) saying: "There are three unfilial acts, and to have no posterity is the greatest of them" (*pu hsiao yu san, wu hou wei ta*).[1] Failure to support one's parents enduring poverty is only second to it, for by failing to have posterity one offends against the whole line of one's ancestors by putting an end to the sacrifices due them. To this belief is due the universal practice of early marriages which has always prevailed in China.

The exceptional checks we find to a large increase of the population are, however, quite as potent as the encouragements to its increase just mentioned. Among these, famine, floods, and pestilence have been the most constantly operating, and have arrested rapid increase more even than the losses incurred through the fearful butcheries which have throughout China's history invariably accompanied the suppression of every rebellion, the establishment of every new dynasty.

Alexander Hosie in his paper on "Droughts in China from A. D. 620 to 1643,"[2] or during a period of 1,023 years, found that drought

[1] Mencius, Bk. IV, Pt. i, Ch. xxvi.

[2] Hosie's inquiries, drawn from the great Chinese work called the *T'u-shu chi ch'eng* (see *Journ. Ch. Br. Roy. Asiat. Soc.*, N. S., XII, 51 et seq.), may be summarized as follows:

Between A. D. 620 and 700, inclusive, there were 41 years with droughts, of which 2 were the results of great floods.

From 701 to 800, inclusive, there were 46 years with drought. In 790 typhus raged.

From 801 to 900, inclusive, there were 43 years with drought, 8 of which were of great severity.

From 901 to 1000, inclusive, there were 60 years with drought, 13 being "great droughts."

From 1001 to 1100, inclusive, there were 68 years with drought, 6 being of long duration, 8 "great droughts" and one (1086–87) universal and of long duration.

From 1101 to 1200, inclusive, there are 60 recorded droughts, of which 9 were "great droughts," 4 of long duration and 5 "very severe."

From 1201 to 1300, inclusive, there were 76 droughts, of which 12 were "great droughts" and 4 "very severe."

From 1301 to 1400, inclusive, there were 59 years with drought, of which 25 were "great droughts," 4 accompanied with floods in other sections of the country, 4 with locusts, and during 6 of the droughts the people resorted to cannibalism.

From 1401 to 1500, inclusive, there were 57 years with drought, of which 36 were "great droughts"; during 8 cannibalism is recorded, and during several typhus raged.

had occurred in 583 years in some one of the eighteen provinces, frequently in four or five of them at the same time, and in many cases they were accompanied by floods, typhus, and other scourges. Frequently these droughts lasted in the same section of country for several successive years or occurred at such close intervals that the country had not time to recover from them. To cite but two cases: from A. D. 1601 to 1643 drought is recorded in some one province of China in 30 years, in 15 of which it occurred in the province of Shan-hsi, and in 11 in that of Che-kiang.

The fearful loss of life which has marked every calamity that has visited any part of China, and the nearly incredible cruelty which has been shown in the suppression of every uprising that has taken place from the earliest days down to the present time, are unfortunately too well authenticated to be denied.

Without going back to the early annals of the Chinese for examples of the terrible mortality which has always attended natural calamities and warfare in China, a few in the last three centuries, vouched for by reliable European writers, or by foreigners resident in the country at the time of their occurrence, may be cited here.

Father Du Halde[1] states that in the year 1582 "there was such a great drought in the Province of Shan-hsi, that it was impossible to count the number of those who died of starvation. There were dug in various localities some sixty great ditches, each of which held a thousand corpses, and were therefore called Van gin keng" (*Wan jen k'êng*), "Grave of a myriad men."

The same author[2] says that on September 2, 1678, there was an earthquake in the Province of Chih-li when over 30,000 persons lost their lives in the town of T'ung chou alone. On November 30, 1731, there was another earthquake in the same province, when over 100,000 persons lost their lives in Peking, and more than that number in the adjacent country.

Father Amiot,[3] writing from Peking, May 20, 1786, tells of a terrible drought which for the three past years had visited the prov-

---

From 1501 to 1600 there were 84 years with drought, of which 69 were "great droughts" (in A. D., 1568, it extended over 8 provinces); during several cannibalism is recorded.

From 1601 to 1643 there were 15 years with drought. In 15 years it occurred in Shan-hsi and in 11 in Che-kiang.

[1] *Description*, I, p. 522. The expression *Wan jen k'êng* is colloquially used to designate a pit into which the bodies of executed criminals are thrown. See H. A. Giles, *Chin. Dict.*, s. v., *k'êng*.

[2] Ibid., I, p. 543.

[3] *Mém. concernant les Chinois*, XIII, p. 425.

inces of Kiang-nan, Ho-nan, and Shan-tung. The people in vast numbers sought to reach other provinces, but thousands upon thousands died on the roads and their corpses were devoured by the survivors.

As regards the extraordinary loss of life attending military operations in China, Du Halde states[1] that in 1635 the Chinese, to defend the city of K'ai-feng Fu in Ho-nan against the rebels, cut the Yellow River dykes. The whole city was submerged and 300,000 persons lost their lives.

The history of Ch'ang Hsien-chung, told by Du Halde,[2] by Father d'Orleans,[3] by Father de Mailla,[4] and others, is an example of what has frequently occurred in China during its long history. In the disturbed period which followed the overthrow of the Ming dynasty, this person overran with his troops the provinces of Ho-nan, Kiang-nan, Kiang-hsi, and Ssŭ-ch'uan. It is said that for the slightest offense not only was the offender himself put to death, but the same punishment was visited on all the inhabitants of the same street. Five thousand eunuchs were beheaded because one of their number refused to treat him as Emperor. He called some 10,000 students to the examinations at Ch'êng-tu Fu in Ssŭ-ch'uan and had them all put to death. He had butchered over 600,000 persons in that province alone! On leaving Ch'êng-tu to march into the adjoining province of Shen-hsi, he had all the inhabitants chained, led out of the city, and executed. Then he ordered his soldiers to put to death their own wives as troublesome impediments in times of war, and he gave the example by having his own wives executed. So reads his story; if it is not all true, much of it certainly is.

Turning to the XIX century, always on the authority of careful European investigators, Colonel Kuropatkin (the present Commander-in-chief of the Russian army in Manchuria) speaking[5] of the Mohammedan rebellion in Shen-hsi and Kan-su of 1861 and subsequent years, states, on the authority of Sosnovski, that on the occasion of the siege of Ho-chou in Kan-su, which lasted seven months, 20,000 men were put to death by the Chinese on the fall of that place. When the neighboring town of Hsi-ning Fu was captured, 9,000 were put to death; at the capture of Chin-chi P'u, the Mohammedan

[1] Op. cit., I, p. 530.

[2] *Description*, I, p. 535.

[3] *History of the Two Tartar Conquerors of China*, Hakluyt Society edit., p. 26.

[4] *Hist. Gén. de la Chine*, X, 470–479; XI, 17–28.

[5] *Kashgaria*, English trans., p. 155.

stronghold, 50,000 were killed and a vast fruitful and thickly populated tract turned into waste. At Chuguchak and its environs 40,000 men perished at the hands of the Chinese, and the town was left without a single inhabitant.

Doctor Macgowan, who was residing in China during the whole of the T'ai-p'ing rebellion, says of it:[1] "Nine provinces had been desolated by it; flourishing towns and cities had been made heaps of ruins, and wild beasts made their dens within them; whilst fully thirty millions of people had been put to death by these ruthless robbers" (rebels and imperialists).

Another authority says: "During the first year of the great Taiping rebellion the registered population declined by two-fifths, but, though many millions must have perished, it is not at all likely that the numbers of 1850 (414,493,000) were more than decimated. Even then, to kill or starve 43,000,000 people in ten years, would mean 12,000 a day, in addition to the 40,000 a day who (at the rate of 30 per thousand per annum) would die naturally, and would balance about the same number of births. Moreover, the rebellion covered only one-half the area of China, so that 24,000 a day is certainly nearer than 12,000.[2]

The loss of life attending the crushing of the two Mohammedan and the Nien-fei rebellions (1860–75) mounted certainly to over a million. Then we have a quarter of a million killed in the suppression of the Mohammedan rebellion in Kan-su in 1894–95. If we add to this terrible source of loss of population that resulting from famines and floods, the total is nearly doubled. There were great famines in 1810, 1811, 1846, and 1849, which, according to the *Tung hua lu,* the best official authority we have on the subject, reduced the population by 45,000,000. Although this figure may seem excessive, we know that in the next great famine—that of 1877–78, which visited only four provinces of the Empire with great severity, no fewer than 9,500,000 persons fell its victims. This figure I quote on the authority of the China Famine Relief Committee of Shanghai.

We must add to this again the loss of life which attended the great flood of 1888, when the Yellow River broke its banks and flooded nearly the whole province of Ho-nan. According to memorials sent at the time to the Emperor, about 2,000,000 were drowned or starved to death by this catastrophe. Then there is the unknown, but certainly terrible, mortality during the great drought and famine in

[1] *History of China,* p. 575. Conf. S. Wells Williams, *The Middle Kingdom,* II, 623.

[2] E. H. Parker, *China,* p. 190.

Shan-hsi, Shen-hsi, Chih-li, and southern Mongolia in 1892–93 and 1894. There have also been numerous epidemics of cholera and plague which have devastated sections of the Empire in the last twenty to thirty years, and still we have not exhausted the list of causes of violent fluctuations, of extraordinary loss to the population of China during the XIX century.[1]

It must not be lost sight of that these figures represent only the mortality among adults; it is extremely improbable that infants were counted at all.

Popoff, in his study on the population in China,[2] estimates that the population of China proper has not only not increased during the period of forty years, from 1842 to 1882, but has even diminished by the considerable number of 30,942,592.

The only reliable data I have found on the subject of Chinese vital statistics are the following:

In 1880 the Governor of the Province of Che-kiang reported[3] to the Emperor that as the result of a general census of the Province taken in 1879, it was found that the population was 11,541,054.

Mr. Popoff, the Interpreter of the Russian Legation in China, was informed in 1882 by the Board of Revenue in Peking that the population of this same province of Che-kiang was then 11,588,692, and in 1885 the same Board informed the writer of the present paper that it was then 11,684,348.

As corroborative evidence of the value of these figures, we learn that Commissioner of Customs Alfred E. Hippisley[4] found by a careful report made to him by the Taotai of the Prefecture of Wen-chou that the average number of persons per home was about 5.14, and that the total population of the prefecture was 1,841,690. "The area of the Prefecture being about 4,500 square miles, the average population would therefore seem to be about 409 to the square mile in this prefecture, and thus largely in excess of the general average of the province."

The best available information concerning the area of the province of Che-kiang[5] gives it as 34,700 square miles. Assuming, then, that

---

[1] I was told in 1901 by the late Li Hung-chang that over 30,000 Chinese lost their lives in Peking alone during the Boxer troubles of 1900. Admitting that this figure and all those here given are exaggerated, it is true beyond all doubt that the loss to the population from these causes has been fearful.

[2] P. S. Popoff in *Novoe Vremya*, No. 3066, 10th Sept., 1884. Conf. S. Wells Williams, *The Middle Kingdom*, I, 270.

[3] *Peking Gazette*, March 17, 1880.

[4] *Trade Report of Wen-chou for 1881*, pp. 27–28.

[5] *Statesman's Year Book*, 1902, p. 495. It may be said that the returns for

the average population to the square mile is one-fifth less than in the Prefecture of Wen-chou (say 325 to the square mile), the total population of the province in 1881 would have been about 11,145,000 —a figure substantially agreeing with that given by the Governor of the Province for 1879 and that supplied Popoff in 1882.

The population of Che-kiang, according to the above figures, increased from 1879 to 1882—say about three years (1880–81) from 11,541,054 to 11,588,692, or 47,638. From 1882 to 1885 (also three years) it increased from 11,588,692 to 11,684,348, or 95.656. This would be an annual increase from 1879 to 1882 of 0.206 percent, and from 1882 to 1885 of 0.275 percent, or an average yearly rate from 1879 to 1885 of 0.240 percent—this under the most favorable possible circumstances, the country being blessed with peace and plenty during all that period and for some years previously. At this rate the population of Che-kiang would double itself by natural increase in 417 years.

Newsholme,[1] calculating the average birth-rate and death-rate for the five years 1891–95, found that in Prussia the population would double itself by natural increase in 49.2 years; in England in 59.1 years; in Italy in 65.7 years; in Austria in 74.1 years; and in France in 591 years, the annual increase in the period named averaging in the latter country only 0.08 per 1,000. Conditions of life in other provinces of the Empire of China are approximately the same as in Che-kiang—in fact, in a number they are worse, particularly as regards the frequency of famines, floods, and epidemics; nevertheless, Chinese enumerations would have us believe that the population in China increases more rapidly than in the most favored countries of the world.

In the case of China, natural increase is the only one to be taken in line of count; immigration into China is practically nil, and emigration from China proper to other portions of the Empire, excluding Asia, has only within quite recent times become of considerable size, and even now it is not sufficient to appreciably affect the sum total of the population in the approximate count we are trying to make of it. The only migratory movements of the Chinese have been from province to province of the Empire. Without going far back into the past, it will suffice to mention the repopulation of the provinces of

Che-kiang show just the contrary of what I am seeking to prove, but it must be seen at once how fanciful must be the returns of population when the total number in a vast province is deduced from a rough count in a small district. This is substantially the method the Chinese follow.

[1] *Elem. Vital Statistics*, p. 15.

Ssŭ-ch'uan and Yün-nan after the Manchu conquest from the Hu Kuang provinces and the similar movement to Ssŭ-ch'uan during the great T'ai-p'ing rebellion. The emigration from Shan-hsi into southern and eastern Mongolia after the famine of 1877–78, and that from Shan-tung and Chih-li into Manchuria still going on—are the most important recent movements of population to outlying parts of the Chinese Empire. The emigration to southern Asia and to remoter parts of the world is drawn exclusively from the provinces of Fu-kien and Kuang-tung, and though considerable, is not so large as to affect to any appreciable degree the rough figures of population we hope to establish.[1]

Very little accurate information has come to us as to the death-rate in any given locality of China; in fact the only official data I know of is the death-rate in Peking during one year, 1845, for which year we have also the returns of a detailed census of the population within the Peking city walls. These were obtained by Sacharoff and published in his valuable study, cited previously. According to them the population of Peking within the walls in 1845 was 1,648,-814, and the number of deaths (exclusive of infants and small children—say under 5 years of age) during the whole year was 39,438,

[1] The following figures relative to Chinese emigration, taken from *Export* of April 14, 1904, a German paper devoted to commercial geography, first appeared in Gottwaldt's work on Chinese emigration. The greater part of the Chinese emigration originates in the southern Provinces, Shan-tung being the only northern Province that furnishes any large proportion of emigrants from China.

The number of Chinese outside of China is as follows:

Country	Number.	Country.	Number.
Formosa	2,600,000	Macao	74,568
Siam	2,500,000	Burma	40,000
Malay Peninsula	985,000	Australia	30,000
Sunda Islands	600,000	Asiatic Russia	25,000
Hongkong	274,543	Japan	7,000
America	272,829	Korea	3,710
Indo-China	150,000		
Philippines	80,000	Total	7,642,650

The following figures show the number of persons that left China and Hongkong and returned during the last twenty-six years:

China and Hongkong.	Left.	Returned.
Amoy (Fu-kien)	1,629,947	1,309,787
Swatow (Kuang-tung)	1,794,298	1,307,744
Kiung-chou (Hai-nan)	298,772	296,233
Hongkong	1,130,000	1,090,000

or about 23.9 per 1,000 inhabitants—by no means an excessive rate.

The death-rate among infants resulting from the highly insanitary conditions in which the whole population, rich and poor, throughout the Empire constantly lives, and also from female infanticide, must be exceedingly high. This latter cause of infant mortality is accountable for a considerably increased death-rate in the Provinces of Kuang-tung, Fu-kien, Che-kiang, Shan-hsi, Kiang-hsi, An-hui, and in most of the other provinces of the empire in a lesser degree.[1]

Everything considered—especially the fact that in a very large part of China the people live huddled together in towns and villages, and that nowhere is any attempt ever made toward sanitation or the prevention of the spread of contagious disease—it seems quite safe to put the death-rate in China at 30 per 1,000 *as a minimum.*

III

Let us revert now to the figures given by the Chinese government for the population at the various periods since 1741 and see whether the annual rates of increase are at all reasonable. This examination is distinctly disappointing; nothing less satisfactory could be conceived. Between 1743 and 1783—during which time China enjoyed extraordinary peace and prosperity, disturbed only by some uprisings of aboriginal tribes in the mountainous regions of the west, and two small rebellions, one in Shan-tung in 1777, the other in Shen-hsi in 1781—no great famines or other natural calamities are recorded. Nevertheless, the annual rate of increase of the population (the enumerations being all presumably made in the same manner, with the same classes excepted), which between 1743 and 1749 was 2.90 percent, fell from 1749 to 1757 to 0.91 percent, to rise between 1757 to 1761 to 1.37 percent, falling again to 0.73 percent between 1761 and 1767 and to 0.57 percent from that date to 1771. The next change is phenomenal: between 1771 and 1776 it was 5.0 percent, but immediately after, between 1776 and 1780 it fell, without any known reason, to 0.86 percent, to rise again between that date and 1783 to

[1] See *Journ. Nor. Ch. Br. Roy. Asiat. Soc.*, vol. xx, p. 25, et seq. Newsholme (*Elem. Vital Statistics*, 130) says that infant mortality in Europe is lowest in Ireland with 164.6 in every 1,000, and highest in Russia in Europe with 422.9 in every 1,000. It must be at least this in China. In Japan, where there exists the same desire as in China to have posterity, the average number of children to a marriage is about 3.5 (Newsholme, op. cit., p. 70). I see no reason to believe that the Chinese are more prolific. In the United States, according to the census of 1900, the annual death-rate of the whites, where accurately recorded, was about 17.8 per 1,000.

2.34 per cent. The average annual rate of increase during the whole period was 1.83 percent. In Japan, where much more favorable conditions exist than in China, the average yearly increase of the population from 1872 to 1899 has been only 1.04 percent.

If we accept the figure given for the population in 1741 (143,412,-000) as being closer the truth than subsequent ones, and bearing in mind the reasons given previously for and against a rapid increase of population, we may assume that the population of China proper barely doubled in the hundred years following; consequently in 1842, instead of being, as given in the official enumeration, 413,000,000, it was probably about 250,000,000.

Referring now to the extraordinary causes of mortality from 1842 down to the present day, some of which are mentioned on preceding pages, they may be tabulated as follows:

		Resulting loss of population.
1846	Famine	225,000
1849	Famine	13,750,000
1854–'64	T'ai-p'ing rebellion	20,000,000
1861–'78	Mohammedan rebellions	1,000,000
1877–'78	Famine	9,500,000
1888	Yellow River inundation	2,000,000
1892–'94	Famine	1,000,000 (?)
1894–'95	Mohammedan rebellion	225,000
	Total loss of adults	47,700,000

We are therefore led to the inevitable conclusion that the present population of China proper cannot greatly exceed that of 1842, a conclusion reached by another line of argument in 1881 by my friend A. E. Hippisley in his too brief study above referred to, and by Mr. Popoff in 1884.

The following considerations tend to strengthen this opinion: The most recent enumeration of the population of China which can lay claim to any value, is that of 1885. In it we find that the returns given for six provinces (Chih-li, An-hui, Kan-su, Kuang-hsi, Yün-nan, and Kuei-chou) are the same as those given in the earlier census of 1882, but which in this latter were in reality for the year 1879. A comparison of the official estimates for these provinces with the estimates made by careful foreign investigators is highly interesting.

In the case of the province of Ssŭ-ch'uan, which the Board of Revenue estimated at 71,073,730 in 1885, all foreign writers agree that it is quite impossible to believe that any such population exists—or can exist in it. Its western, northwestern, and southwestern parts are extremely mountainous and very sparsely inhabited; furthermore, the province contains no extremely populous cities; Ch'êng-tu, the capital, has about 350,000, and Ch'ung-k'ing about 130,000.

The Lyons Commercial Mission, speaking of the year 1895–96, states its belief that the estimates of the Maritime Customs at Ch'ung-k'ing for 1891 of 30,000,000 to 35,000,000 for the province of Ssŭ-ch'uan is too low, but accepts that of from 40,000,000 to 45,000,000.[1] G. J. L. Litton, writing in 1898, estimated the population of Ssŭ-ch'uan at more than double that given in the enumeration of 1812, and put it at 43,000,000.[2] F. S. A. Bourne, also writing in 1898, says that the population of Ssŭ-ch'uan is probably between 45,000,000 and 55,000,000. In a report in 1904 Hosie gives it as 45,000,000.[3]

Kiang-hsi, for which the official returns give a population of more than 24,000,000, is believed by W. J. Clennell, writing in 1903, to have less than 12,000,000.[4] The same writer estimates the population of Fu-kien in 1903, at "certainly under 10 millions," whereas the Chinese figure for 1885 is 23,502,794. As regards Yün-nan, the Lyons Mission[5] puts the population in 1896 at from 7,000,000 to 8,000,000. F. S. A. Bourne, writing of Yün-nan in 1896, says that "according to the best native authority the population is estimated at one-fifth of what it was before the (Mohammedan) rebellion";[6] while Litton, in 1903, thought it was "not over 10 millions."[7] The Chinese estimate of the population of this province in 1879 (the same figure is given for 1885) was 11,721,576, but only two years before that, in 1877, General Mesny[8] placed it at 5,600,000.

Kuei-chou, in or about 1896, was thought to have about 7,000,000 inhabitants,[9] in this agreeing with the Chinese estimate.

Without going any farther we see that for the five provinces above mentioned, foreign investigators substantially agree that the Chinese estimates are too large by some 56,000,000. All the Chinese figures are one-half to one-third too high. I have not the least doubt that the same reduction must apply to the estimates for most of the other provinces, the error in excess increasing presumably with the density of the population. The conviction is therefore forced on me that the present population of China proper does not exceed 275,000,000—and is probably considerably under this figure.

---

[1] *Mission Lyonnaise d'explor.-commer. en Chine, 1895–97*, part II, p. 232.

[2] *Brit. Cons. Reports, No. 457*, Misc. series.

[3] *Brit. Cons. Reports*, No. 458, Misc. series, p. 49. *Blue Book; China, No. 5 (1904)*, p. 4.

[4] *Brit. Parl. Blue Book; China, No. 1, 1903.*

[5] Op. cit., part II, p. 129.

[6] *Rep. Blackburn Chamber Commerce*, p. 91.

[7] *Brit. Parl. Blue Book; China, No. 3, 1903.*

[8] *Journ. Ch. Br. Roy. Asiat. Soc.*, XXV, p. 483.

[9] *Mission Lyons.*, part II, p. 207.

The population of China is most unevenly distributed; in certain sections for example, around Swatow, and in portions of Ho-nan, Shan-tung, and Chih-li, it is extraordinarily dense, while in others, as Kan-su, Yün-nan, Kuei-chou, and Kuang-hsi, it is surprisingly sparse. Guesses of the population based on partial returns from some densely populated center would give a most erroneous idea of the population not only of the province as a whole, but of even a smaller division of the country. I have traversed several times all the northern provinces of China—Chih-li, Shan-hsi, Shen-hsi, and Kan-su—and can vouch for the fact that in none of them does the population appear to exceed in numbers what the soil can easily support. The absence of easy lines of communication over which surplus produce can be readily exported, and the fact that the Chinese do not raise cattle or any domestic animals in considerable numbers, tend to restrict the areas cultivated by the farmer. It seems certain that China could support a much larger population than it now has—a condition which could not exist if the population had reached the enormous figure which imaginative writers give us. I am confirmed in this opinion by such a careful observer as F. S. A. Bourne, who referring to the journey of the Blackburn Chamber of Commerce Mission,[1] which traversed the whole Yang-tzŭ valley and southwestern China, says: "From what we have seen on this journey I should say that China could support twice her present population, and that each man might be twice as well off as he is now; and this without any revolutionary change in their present manner of life."[2]

[1] *Rep. of Mission to China of Blackburn Chamber of Commerce*, 1896–97, p. 111.

[2] In a most interesting study entitled *Tenure of Land in China and the Condition of the Rural Population* (*Journ. Ch. Br. Roy. Asiat. Soc.*, N. S., XXIII, pp. 59–174), we find it stated (pp. 76–79) on excellent authority that "it is impossible to say with any sort of exactness what proportion of the whole soil of China is tilled by peasant owners, but probably it cannot be put at less than one-half. The other moiety is owned in great measure by retired officials and their families, the class known as the literati and gentry. . . . Considerable tracts of land are owned by such families, and it is the invariable rule in these cases to lease the land to small farmers. In the central and populous parts of China these holdings are exceedingly small, often less than an English acre, seldom larger than three or four acres. . . . Most lands yield one or more subsidiary crops in the course of the year, besides the principal crop. . . . On the frontier provinces, where the soil is poorer and the population more sparse, the size of the holdings is in general much larger than in the central provinces, and the people would seem as a rule to be better off. But as population increases there seems everywhere to be a strong tendency for holdings to become reduced to the minimum size that will support a single

ENUMERATIONS OF THE POPULATION OF CHINA, 1761–1885.

PROVINCES.	1761	1812	1842	1882	1885
Chih-li	15,222,040	27,990,871	36,879,838	17,937,000*	17,937,005*
Shan-tung	25,180,734	28,958,764	29,529,877	36,247,835	36,545,704
Shan-hsi	9,768,189	14,004,210	17,056,925	12,211,453	10,791,341
Ho-nan	16,332,570	23,037,171	29,069,771	22,115,827	22,117,036
Kiang-su	23,161,409	37,843,501	39,646,924	20,905,171	21,259,989
An-hui	22,761,030	34,165,059	36,596,988	20,596,988*	20,596,988*
Fu-kien	8,063,671	14,779,158	25,799,556	25,000,000	23,502,794
Che-kiang	15,429,692	26,256,784	30,437,974	11,588,692	11,684,348
Hu-pei	8,080,603	27,370,098	28,584,564	33,365,005	33,600,492
Hu-nan	8,829,320	18,652,507	20,048,969	21,002,604	21,005,171
Shen-hsi	} 7,412,014	10,207,256	10,309,769	8,432,193*	3,276,967
Kan-su		15,354,875	19,512,716	5,411,188*	5,411,188*
Ssŭ-ch'uan	2,782,976	21,435,678	22,256,964	67,712,897	71,073,730
Kuang-tung	6,797,597	19,174,030	21,152,603	29,706,249	29,740,055
Kuang-hsi	3,947,414	7,313,895	8,121,327	5,151,327*	5,151,327*
Yün-nan	2,078,802	5,561,320	5,823,670	11,721,576*	11,721,576*
Kuei-chou	3,402,722	5,288,219	5,679,128	7,669,181*	7,669,181*
Kiang-hsi	11,006,640	23,046,999	26,513,889	24,534,118	24,541,406
	190,257,423	360,440,395	413,021,452	381,309,304	377,636,198

The figures given in the censuses of 1761, 1842, 1882, and 1885 were supplied to Father Amiot, Sacharoff, Popoff, and Rockhill by the Chinese Board of Revenue. Figures in the returns for 1882 and 1885 marked with an asterisk are those given to Sacharoff for the year 1879. They are the latest official estimates.

The figures given under the census of 1812 are taken from Sacharoff, whose authority was presumably the official Ta Ch'ing Hui-tien.

---

family. The more fertile the soil the smaller the farms and the more minute the subdivision. How marvellously fertile the soil is under favorable circumstances will be seen from the fact that . . . one *mow* (6.6 to an acre) will support one individual. On this basis a square mile is capable of supporting a population of 3,840 persons."

THE SEEDS OF ANEIMITES[1]

By DAVID WHITE

In the spring of 1900, while studying some of the collections of fossil plants from the lower Pottsville formations of the Virginian region, I was more than surprised at finding among the fossils from one locality numerous examples of a small fruit, which I had previously regarded as a new gymnospermic genus, attached by pedicels to rhachial fragments that, on account of their organic union with sterile pinnules, can not be regarded otherwise than as belonging to the fern genus commonly known as *Adiantites*. Detached specimens of these fruits had been found at a number of localities, and, on account of their external characters and their evidently deciduous habit, no question had arisen in my mind as to their seed nature. It had indeed been noticed that they were intimately associated with *Adiantites* foliage, but I was then quite unprepared to recognize them at once both as seeds and as belonging to fronds whose fern nature had hitherto been unquestioned.

At that time the sterile fragments and the correlated fruits were fully treated in my manuscript, in preparation, on the Pottsville floras, the name *Wardia* being given to the generic type of fructification. But, appreciating the gravity and the far-reaching importance of attributing seeds to a long established Paleozoic genus whose every character was pteridophytic, I postponed all special publication of the matter in the hope that further study in the course of the elaboration of the collections from hundreds of Pottsville localities would yield cumulative evidence bearing either on the internal organization of the fruits or on the structure of the fronds. The segregation as " Cycadofilices " of a number of types, principally stems and petioles, combining certain filicate and gymnospermic, particularly Cycadean, characters of structure, had already been established by Potonié,[2] and representatives of the sterile-frond genera *Sphenopteris, Neuropteris,* and *Alethopteris* had more or less definitely been referred to the group; but no type of fruit had been satisfactorily correlated with any member of that group.

---

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] *Lehrbuch der Pflanzenpalæontologie,* 1899, p. 160.

Since the discovery of the relation of the seeds to *Adiantites,* my examinations have not only shown the generic type of fruit to be present at most of the places where *Adiantites* is found in the Pottsville formations, but they have also revealed different forms of the *Wardia* seeds in the most intimate association with four other species of the fern genus, with one of which, *Adiantites tenuifolius,* it is, again, in actual union.

Meanwhile the especial interest aroused by the correlation by Oliver and Scott,[1] on the basis of anatomical characters, of the seeds described by Williamson as *Lagenostoma* with *Lyginopteris* and, through the latter, with the *Hoeninghausii* group of Spenopterids; and the discovery by Kidston[2] of a Rhabdocarpous seed attached to the frond of *Neuropteris heterophylla,* as well as the arguments from distributional association set forth by Grand'Eury[3] make timely the presentation of the data relating to the Cycadofilic character of the hitherto unsuspected genus *Adiantites.*

Unfortunately a nomenclatorial change for *Adiantites* is at the outset necessary, the type section of the genus as proposed by Goeppert[4] being composed of species of *Ginkgo.* The name is therefore untenable in its restricted application as employed by Schimper, Stur, and others and as now generally recognized. The emended genus is indistinguishable from the American plant to which Dawson gave the name *Aneimites.* The latter name, as indicated by Etheridge,[5] is valid, as the eligible name next in priority, for the genus. Accordingly hereafter in this paper *Aneimites* will be used for *Adiantites.*

The specimens to be described were collected from a cut along the Keeney Creek branch of the Chesapeake and Ohio railway on the mountain side back of Nuttall, West Virginia. The horizon is in the Thurmond formation (lower Pottsville) about 350 feet below the Raleigh sandstone.

The plant, a new species typical of the genus *Aneimites* (*Adiantites*) may be described as follows:

ANEIMITES (WARDIA) FERTILIS n. sp.

(PLATES XLVII AND XLVIII)

Fronds quadripinnatifid, or quadripinnate?, spreading, a little delicate, but hardly lax, and rather dense, the divisions of the rachis

[1] *Proc. Roy. Soc.,* vol. LXXI, 1903, p. 477.
[2] *Proc. Roy. Soc.,* vol. LXXII, 1903, p. 487.
[3] *Comptes Rendus,* vol. 138, 1904, p. 607; vol. 139, p. 23.
[4] *Syst. filic. foss.,* 1836, p. 216.
[5] *Proc. Linn. Soc. N. S. W.* (2), vol. III, pp. 1301, 1302.

being slender, somewhat rigid except at the periphery of the frond, very finely striate, sparsely and obscurely punctate, rounded dorsally, shallowly canaliculate ventrally, the ultimate rachis being slightly flexuose and bordered by a very narrow wing of the decurrent lamina; penultimate pinnæ alternate or subalternate, open at or nearly at a right angle, close, usually touching or overlapping somewhat, linear or linear-lanceolate, acute or acuminate, and provided with large pinnatifid and fasciculately lobed pinnules above the ultimate pinnæ, the uppermost being sublobate or simple and narrowly cuneate; ultimate pinnæ alternate, subalternate, or sub-opposite, close, more or less open, usually rigid, overlapping a portion of their width, ovate to lanceolate or linear-lanceolate, obtuse or acute when sterile, attenuated and curviramose above when fertile. Pinnules alternate to subopposite, of greatly varying size, 3 mm.–18 mm. in length, the lobes or divisions being 1 mm.–3.5 mm. in width, narrowly cuneate, occasionally narrowly spatulate, the lateral margins slightly convex above, often slightly concave near the narrow or slightly subpedicellate base, the upper pinnules of the sterile pinnæ being very narrow and simple, becoming bifid, and bi-or tri-foliately dissected to or nearly to the base in 3–5 palmately or somewhat fasciculately radiating lobes or fully developed pinnules on an elongating axis, the apices being rounded, or truncate-rounded, more or less oblique, sometimes emarginate, the distal basal pinnule or lobe being usually noticeably broader than the other lobes or pinnules in the fascicle, while the proximal basal pinnule is often reduced in size, and more narrowly lobed; lamina very thin, decurring in an extremely narrow wing along the rachis, and minutely rugose-striate when viewed under a strong lens. Nervation very thin, but usually distinct and very slightly in dorsal relief; primary nerve strongly decurrent, forking once or twice at a wide angle in the base of the pinnule the nervilles forking once or twice at narrower or moderate angles, in passing upward, thread-like, often appearing double, nearly parallel and not very close, to the apex of the pinnule in which they often appear to slightly converge.

Fertile portions of the frond peripheral, laxly ramose at the apices and somewhat reduced as to lamina, the pinnules in the upper portions of the pinnæ becoming very small and distant, the lobes sometimes slightly thickened. Fructification (*Wardia*) small, rhomboidal, thin, deciduous, borne usually singly, but rarely doubly, in sparsely paniculate arrangement at the dilated apices of thick nervose-lineate, distantly, elongately, and faintly punctate, ramose pedicles which correspond to the greatly elongated and thickened

Explanation of Plate XLVII

Aneimites fertilis n. sp.

Page 323.

Fig. 1. Fragments of primary (?) pinnæ, showing pinnules of largest proportions.

Fig. 2. Portion of the sterile frond, exhibiting typical pinnæ of the average proportions.

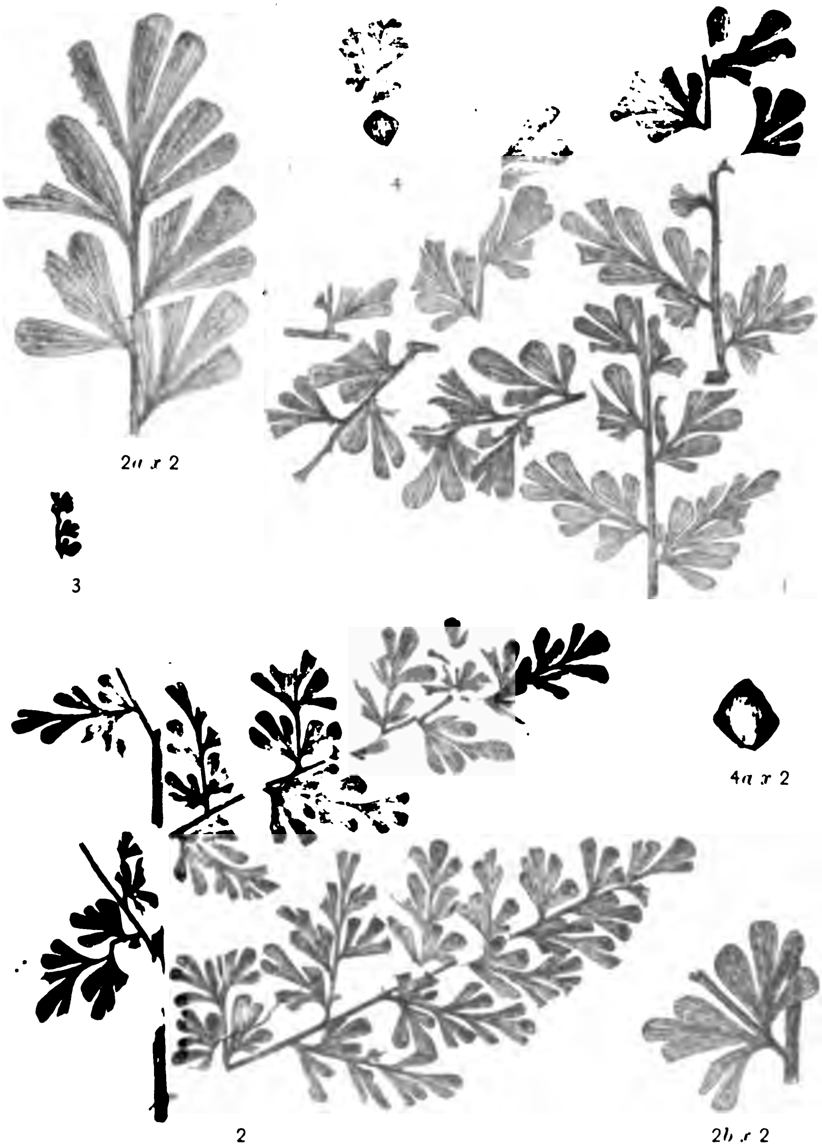
Figs. *2a* and *2b*. Pinnules enlarged to twice the natural size to show the nervation, and the details of the very thin lamina.

Fig. 3. Fragment of pinna, showing the smallest pinnules observed. The specimen is mingled with fertile fragments.

Fig. 4. Fragment of pinna with reduced pinnules, probably proximal to the fertile portions.

Fig. *4a*. Mature and detached seed, enlarged to twice the natural size.

The originals, from Nuttall, W. Va., are in the collections of the U. S. National Museum.



SEEDS OF ANEIMITES

lobes of the reduced pinnules, the somewhat irregularly curved and often bifurcated pedicles constituting the uppermost divisions of the rachis. Seeds oval, rhombic, bilaterally symmetrical, the longitudinal axis averaging 4.5 mm., the transverse being 2.5 mm., rounded at the angles, slightly flatly obtuse at the apex and a little concave at the point of attachment, from which ascends on either side a narrow, striate, rather thick wing formed by a lateral dilation of the outer fibrous envelope, about .3 mm. wide at the base, gradually attaining a maximum width of .75 mm. a little below the lateral angle, narrowing somewhat abruptly above, and often difficult of observation at the apex of the fruit; outer envelope of the seed rugose by fine, irregular, longitudinal striæ, which often pass from the lateral wing to the surface of the nutlet in the compressed specimens, the seeds being also rarely traversed by numerous very obscure ribs; nutlet less distinctly rhomboidal, the lateral angles being less pronounced. Microsporangiate organs not definitely correlated.

The sterile portions of this plant constitute an interesting type which is at once recognizable by its open pinnation, the palmate or fasciculate grouping of the divisions of the lower pinnules, and the distinctly cuneate form, deep dissection, and thin texture of the latter. The pinnules, which are usually somewhat obliquely truncate-rounded, often present a Triphyllopteroid arrangement. A marked specific peculiarity of the frond is the generally greater breadth of the distal lobe of the pinnule or of the distal pinnule in the fascicle.

The general aspect of the foliage of the species is indicated by the fragments illustrated in plate XLVII, figures 1 and 2, the pinnules of the former being of nearly the largest proportions yet found in the collections. Occasionally the pinnules are less compact and more lax, while the fragment shown in plate XLVIII, figure 2, represents the maximum proportionate broadening yet observed in the smaller pinnules. Between those of the larger ones shown in figures 1 and 2 of plate XLVII, on the one hand and the examples with very small pinnules shown in plate XLVIII, figures 1 and 3, or the smallest observed, figure 3, plate XLVII, on the other hand, the sequence is complete and irrefragible. The very small pinnules connected with the fertile portions of the frond differ only in size from the larger leaflets on the barren pinnæ. The lamina, as indicated in the enlarged details (plate XLVII, figures *2a* and *2b*, or plate XLVIII, figure *3a*) is very thin, the thread-like nerves being but slightly in relief dorsally. The dorsal surface is marked by very fine striation and occasional irregular faint lineation, and on the smaller divisions of the rachis by minute elongated punctations.

On examining the plant material from Nuttall I was more than surprised at finding specimens in which the peculiar little rhombic winged fruits (*Wardia*) usually found at other localities in association with the Pottsville *Aneimites* were not only still attached to their stalks, but in actual union with fragments of pinnæ unmistakably bearing the small reduced pinnules of the species described above. These fruits, found abundantly associated with the pinnæ of *Aneimites fertilis* at this locality, appear to present themselves in nearly all stages of development, while many detached mature examples occur scattered on the fragments of shale.

Figure 4, plate XLVIII, exhibits the lax, elongated, and ramose habit of the apical portion of the fertile pinnæ. The rachis becomes less terete and more flexuose, while forking pinnately and distantly below and more closely above. At the same time, with the disappearance of pinnules, the axes become more lax, and spread out thinner in passing upward, the distal lobes or divisions (pedicels) also becoming cuneately expanded at the apices, while revealing several thin nerve-strands, which, in the most dilated apices, give rise to a distant, dichotomous nervation, that, so far as developed, is precisely in agreement with the nervation of the sterile portions of the frond. At the distal margins of these terminal expansions are developed the fruits, usually singly, though rarely two appear on the same pedicel, in which case one is commonly immature or abortive. The more dilated apices, which retain a broader foliar lamina and more distinct nervation, seem at most not to bear more than minute and undeveloped or abortive fruits. Several imperfectly preserved fruits are seen in the specimen figured, while a number of scarred apices mark the points of detachment of other mature specimens.

The characters both of pedicels and of seeds are better shown in a more simply divided example, illustrated in figures 5 and 5*a*, plate XLVIII. This specimen shows well two of the broader, nervose, apical dilations which are seen to be shallowly and broadly digitately lobate. The lobes are always thickened and concavo-convex, and frequently seem to contain a small scar or pit. They are, perhaps, to be regarded as abortive, though it is possible that they may be sporophytic. They are strongly suggestive of a developmental stage of a sporangial type found in association with an undescribed species of *Aneimites* from the base of the Pottsville near Pocahontas, Virginia. Evidently they are less altered from the ordinary foliate type.

At the base of the nearly fully developed seed on the left in the

Explanation of Plate XLVIII

Aneimites fertilis with seeds, *Wardia fertilis* n. sp.

Page 323.

Fig. 1. Fragment of frond, showing small, narrow form of pinnules.

Fig. 2. Example with proportionately broad, though small pinnules.

Fig. 3. Portion of pinna, probably from fertile part of the frond.

Fig. 3*a*. Detail showing characters of the small pinnule and the obscurely lineate and elongately punctate rachis, enlarged to twice the natural size.

Fig. 4. Fertile apical portions of pinnæ, with seeds above and reduced pinnules below.

Fig. 5. Similar fragment with forking, thin pedicels, dilated at the apices.

Fig. 5*a*. One of the pedicels showing a seed and one of the foliate expansions, possibly representing an early stage in the development of the polleniferous organs, enlarged to twice the natural size.

Fig. 6. Seed still attached to the pedicel.

Fig. 6*a*. The same enlarged to twice the natural size to show the collapse of the apex, and the presence of the basal scales or possibly undeveloped ovules.

Fig. 7. Detached mature seeds, one of which is so preserved as to show the outline of the nutlet, and a broken edge of the outer envelope.

Fig. 7*a*. One of the seeds showing (exaggerated) the boundary of the nutlet, and the minute dimples at the angles of the wing, enlarged to twice the natural size.

Fig. 8. Pedicels with young and immature seeds.

Fig. 9. Similar example showing undeveloped and perhaps abortive fruits.

Fig. 10. Seeds obliquely compressed so as to foreshorten the nutlet and reveal the continuity of the wing.

Fig. 10*a*. The same, enlarged to twice the natural size to show the apex of the seed, which, in the diagonally flattened specimen, appears to be papillate.

Fig. 11. Fragment of pinna in which the apices are developed as young seeds.

Fig. 11*a*. The same, enlarged to twice the natural size to show the characters of the young fruits as well as of the pinnules.

Fig. 12. Apical fragments with delicate dichotomous, spiral, lineate appendages, thickened at the tips, possibly representing the microspore-bearing organs of the plant.

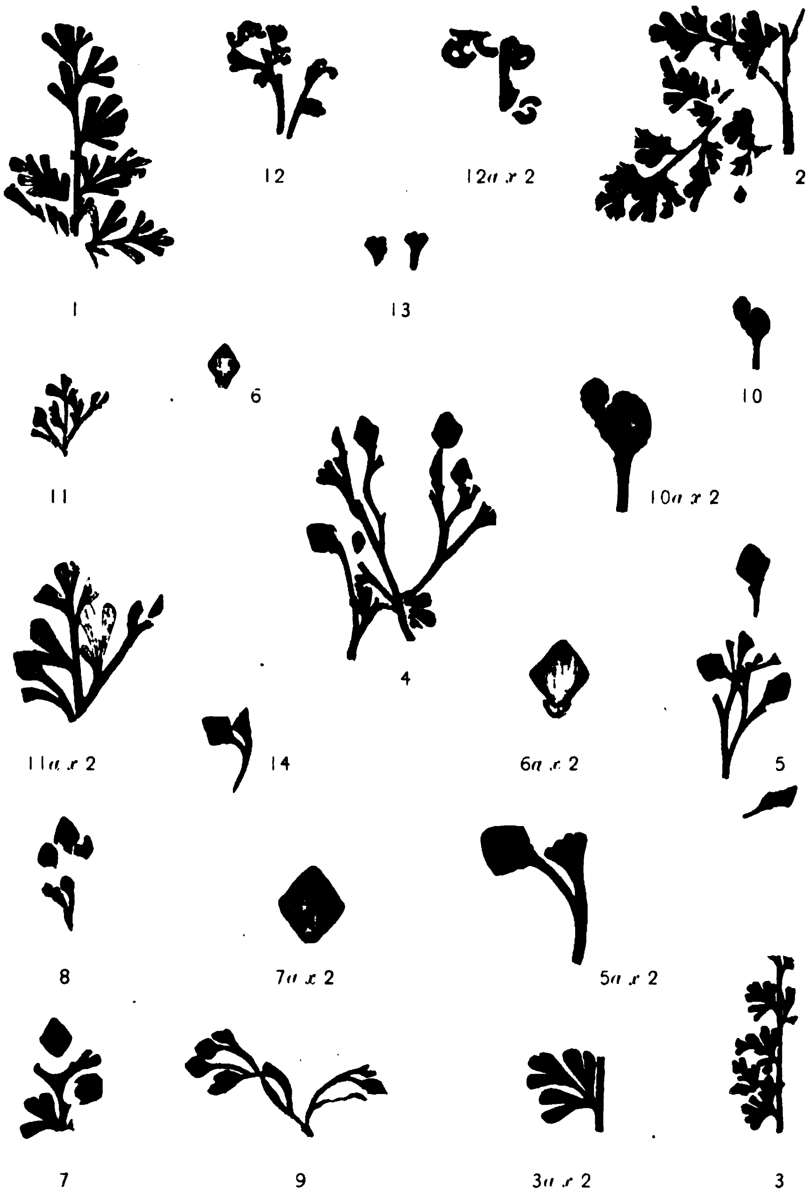
Fig. 12*a*. Portion of the same enlarged to twice the natural size to show some of the spiral appendages which are dense at the apices.

Fig. 13. Apex of a pedicel showing scars, probably those of the attachment of the spiral appendages shown in Figure 12. See similar development at the left of the latter figure.

The portion at the left in Figure 13 is shown enlarged to twice the natural size, and is cited as "*a*" in the text, p. 328.

Fig. 14. Pedicel, from which the seeds have fallen, showing obscure scars of detachment.

The originals, from Nuttall, W. Va., are in the collections of the United States National Museum.



SEEDS OF ANEIMITES

cited figure vestiges of small scales or undeveloped ovules may be noted. This feature, which is often to be observed, is also shown more clearly in the isolated specimen drawn in figures 6 and 6*a*, plate XLVIII. Both of these seeds show indistinct traces of a very slight collapse at the apex, a condition which may be construed as evidence of a pollenic chamber.

In the example just referred to a slight depression or dimple is noticed in the lamina of the wing just at the lateral angle. This character, which is visible in most of the seeds, I construe as possibly indicative of the presence of glands at those points. Figure 5*a* illustrates the vascular lineation of the outer envelope which is continuous from the portion over the nutlet across to the lateral dilation which forms the wing. The outline of the nutlet is rarely revealed by the tearing away of the marginal portion, but is frequently well shown, especially in the lower portions, by the circumstances of preservation, as illustrated by two proximate, mature, and detached seeds shown on the rock in figures 7 and 7*a*. The outer envelope is probably much thinner near the apex of the fruit, and in most cases is hardly distinguishable as a border near the top. The point of detachment, as shown in the figure last mentioned, is uniform in practically all the numerous isolated mature fruits and is evidently accomplished by the development of separative tissue at the base of the mature seed.

In a number of instances the arrangement of the fruits is more crowded, the seeds being borne close above the dichotomy of the pedicel, as suggested in figure 10; and this compactness sometimes lends an aspect of several seeds at the apex of a single pedicel. Fruits that are immature or about half-grown are seen in the fragments, figures 8 and 9. In these specimens a number of the seeds appear to be either imperfect or abortive. The aspect of the single or double fruit accompanied by rudiments, or possibly undeveloped ovules, at the apex of the pedicel is suggestive of the fruits of *Ginkgo*. The marginal wing is quite inconspicuous at this stage of the development of the seed. To the laxity and tenuity of the basal portions of the pedicels, as seen in figure 9, is due the generally detached and fragmentary condition of the specimens and the difficulty of exposing them so as to show a direct connection with the foliate portions of the pinnæ. The example seen in figures 10 and 10*a* is obliquely compressed so as to show the outer envelope completely surrounding the nutlet. In another example, a fragment (figure 11) from the border of the foliate portion of the pinna, a pedicel is developed at the apex of a small lateral pinna, the closely lineate surface of the crushed and immature fruits being precisely in agreement with that of the seeds in figures 4 and 9.

At the apex of the pedicel illustrated in figure 13, a portion of which is enlarged at *a*, we see some of the small scars which should perhaps be regarded as vestiges of abortive ovules, though it is possible that they may have rather to do with the development of spore-bearing organs. In other examples, like that drawn in figure 12, they are found to be associated or apparently originally connected with delicate, very narrow, dichotomous, partially coiled, lineate-nerved, laminate appendages, with slightly thickened apices. The circumstances of their occurrence, and the form of these very delicate and apparently transitory appendages, strongly suggest their function as the polleniferous organs of the plant. Additional evidence is, however, necessary before drawing conclusions in this very important matter. The scars left at the apices of the petioles after the fall of the mature seeds, as imperfectly indicated for comparison in figure 14, are at once distinguishable from those in the specimens shown in figure 13. Ordinarily, however, the abandoned pedicels are seen only in profile and show only the edges from along which their seeds were detached.

The problem of the spore-bearing organs of *Aneimites fertilis* remains to be determined by the future discovery of more conclusive material. I am strongly disposed to believe, however, that they will be found either to be connected with the appendages of the type just described or, less probably, represented by an associated, delicate, small type of *Calymmatotheca* that may possibly have been developed at the distal borders of the more dilated and distinctly venous laminæ seen at the apices of some of the pedicels, like that shown in plate XLVIII, figure 5. The arguments for *Calymmatotheca* are stronger in the case of the Pocahontas plant, already referred to, which will be fully described in the writer's monograph of the Pottsville floras. At no locality have sporangia of the genus last mentioned been found distinctly in union with any species of *Aneimites.*

SUMMARY

In the foregoing pages it has been shown that the fruits of *Aneimites* (*Adiantites* of authors) are borne singly or rarely plurally at the apices of lax, flexuose, ramose, and slightly dilated terminal extensions of the peripheral pinnæ, whose pinnules become greatly reduced in the proximate sterile portions. Each seed may be regarded as corresponding to a lobe or pinnule, whose basal stalklet is usually much elongated. This is illustrated by the specimen shown in plate XLVIII, figure 11.

The seeds, *Wardia fertilis,* are small, oval-rhomboidal, winged fruits, obtusely rounded at the apex, and apparently consisting of an inner nutlet, probably thinly lenticular in cross-section, surrounded by a fibrous and probably somewhat fleshy outer envelope, which is laterally dilated below the angles of the nutlet to form a wing, and which is slightly denser, with larger bundles, near the base. When mature they are regularly and uniformly deciduous by cross scission of the tissue at the base of the nutlet. In the process of their development the pedicels appear to elongate somewhat, while the wing is inconspicuous in the earlier stages. They are usually accompanied, at the dilated summit of the pedicel, by smaller imperfect or abortive fruits, or scales. The evidence of an apical pore or micropylar neck is obscure, while that of a pollenic chamber rests on the occurrence of a slight collapse within the apex of the nutlet, observed in a few examples only. The slight costation noticed in some of the seeds suggests a gymnospermous type with both pollenic chamber and micropyle.

The fruits of *Aneimites* can hardly be regarded as other than true seeds, and the group of hitherto supposed ferns to which they belong is therefore to be referred to the Pteridospermæ of Oliver and Scott, the " Cycadofilices " of Potonié.

The identity and nature of the microspore-bearing organs are not yet determined; but it is highly probable that the production of pollen either has to do with branched and coiled appendages originating at the apices of some of the dilated pedicels, or that, as seems to the writer much more unlikely, it is connected with the intimately associated *Calymmatotheca* type of sporangia.[1]

To the seeds of *Aneimites* described above is given the generic name *Wardia* in honor of Professor Lester F. Ward whose comprehensive elaboration and philosophical discussions of the American Mesozoic floras are an invaluable contribution to our knowledge of the development and distribution of plant life in geological time. The type of the genus is *Wardia fertilis.*

As compared with other Paleozoic seeds *Wardia* is perhaps most suggestive of some of the smallest species of *Cardiocarpon,* though differing from that genus by its fibro-nervose outer envelope, and the diminution of the wing in passing above the middle. It is prob-

[1] The latter hypothesis is in accord with the views of Professor Zeiller, who suggests that the pollen of *Neuropteris* may have been produced by some *Calymmatotheca*. *Comptes Rendus,* vol. 138, 1904, p. 663.

ably more lenticular than any of the small wingless seeds from the Coal Measures placed by authors in *Carpolithes*. As between *Lagenostoma* and *Rhabdocarpos*, the two types of seeds reported to have been definitely correlated with Cycadofilic fronds, it is evidently with the former that the closer relations probably exist, although it is difficult to determine satisfactorily the relations between seeds known chiefly by their internal structure and others known only by the external characters of the compressed specimens. The most prominent differences between *Lagenostoma*, as the latter is described by Williamson[1] or Oliver and Scott,[2] and *Wardia* are the presence of the wing, the thin and lenticular cross-section, and the absence of all traces of radial chambering near the apex, unless the faint costation is to be interpreted as due to the features of the pollenic chamber. *Wardia* has probably two distinct tests; *Lagenostoma physoides*, which has a fibrous layer, perhaps approaches more closely than do *L. ovoides* or *L. Lomaxi*, the latter of which is produced in a costate and deeply lobed cupule. Certain points of resemblance between the two genera include a degree of similarity in size and general form of the seeds, the development of the latter on pedicles, and, to some extent, a common Spenopteroid habit of the sterile fronds. Incidentally the punctation on the rachis and the pedicels of *Wardia* may be homologous with the glandiferous stalks on the pedicel and the cupule of *Lagenostoma*. On the other hand the reduced pinnules of *Aneimites fertilis* are in general form very suggestive of those of the normal *Sphenopteris elegans*, with which *Heterangium*, another Pteridospermic type, is correlated, while the narrow, ventrally sulcate, dorsally round divisions of the *Aneimites* rachis suggest the V-shaped single vascular axis of a *Heterangium* petiole.

On account of certain similarities between the sterile fronds of *Aneimites* and those of the *elegans* and *Hoeninghausii* groups of Spenopterids, together with the consideration of the points of resemblance in the seed production in *Lyginopteris*, I am disposed to regard *Wardia* as more closely related to *Lagenostoma* than to any other Cycadofilic type at present recognized. But, in the absence of knowledge of the internal organization of the rachis of *Aneimites*, and in view of the important external seed differences, the inclusion of the latter genus within the same family (Lyginodendreæ) does not at present seem warranted. However, they may, I believe, with

[1] *Trans. Roy. Soc.*, vol. CLXVII, 1877, p. 233, figs. 53–75; vol. CLXX, 1880, p. 517, figs. 61–63.

[2] *Proc. Roy. Soc.*, vol. LXXI, 1903, p. 477; vol. LXXIII, 1904, p. 4.

reasonable confidence be provisionally included within the broader scope of an order, the *Lyginodendrales*. In accordance with the classification of the supposed Cycadofilic types recently proposed by Professor Lester F. Ward,[1] this order will fall within the class Pteridospermæ,[2] and the phylum Pteridospermaphyta.

The discovery of Pteridospermic characters in *Aneimites,* in which they had not been suspected, throws serious suspicion on the sterile-frond genera, *Eremopteris,*[3] *Pseudopecopteris,* and *Triphyllopteris,* which appear to be most closely connected to *Aneimites* by the characters of their fronds, and whose fructification is wholly unrecognized.

The habitual association of *Wardia* with the foliage of *Aneimites* (*Adiantites*) at a number of localities suggests that the seeds from Altendorf figured by Stur[4] as *Rhabdocarpus conchæformis* Goepp., which resembles *Wardia* in many respects, may possibly be the fruit of one of the species, also from Altendorf, described and figured by the same author as *Adiantites antiquus* and *A. Machaneki.*

[1] *Science,* n. s., vol. xx, Aug. 26, 1904, p. 279.

[2] Oliver and Scott, *Proc. Roy. Soc.*, vol. LXXIII, 1904, p. 4.

[3] Compare *Eremopteris Cheathami* LX.

[4] *Culm-Flora,* pt. 1, pl. xvii, f. 8, 9, p. 81.

THE NEW SPECIES OF BIRDS IN VRCEG'S CATALOGUE, 1764

By C. DAVIES SHERBORN

Vroeg's *Catalogue* is so rare that the only copy I have met with is preserved among Linnæus' collection of books in the library of the Linnean Society of London. The new species of birds (there are no other new species) are collected at the end of the *Catalogue* in a separately-paged " Adumbratiuncula," and as these new species are properly diagnosed, the Linnean Society has kindly consented to a reprinting of the pages. The reprint follows the original, line for line, the only addition being the localities, which have been added from the entries in the *Catalogue* to which the numbers prefixed to each item refer.

There is no clue in the *Catalogue* to the author of the specific names, and in my *Index Animalium* they were attributed to the owner of the collection, but I am informed by Dr. C. W. Richmond that P. S. Pallas was the real author. [A reference to Pallas' *Zoographia Rosso-Asiatica* (II, p. 199, under *Trynga tridactyla*) proves this to have been the case. That Linnæus knew Pallas was responsible for the names and descriptions in Vroeg's *Catalogue* is evidenced by his occasional citation of " *Pallas. adumbr.*," etc., in the twelfth edition of his *Systema Naturæ*, 1766, and without doubt Linnæus was indebted to Pallas for his copy of the *Catalogue*. Pallas was born September 22, 1741, and consequently was twenty-three years of age at the time of this performance. C. W. R.]

Catalogue | raisonne, | D'une Collection supérieurement belle | D'Oiseaux, | Tant exotiques qu'Europe'ens, | de | Quadrupèdes | et | D'Insectes. | Empaillés, & arrangés avec beaucoup d' art en situa- | tions & attitudes extrêmement naturelles, & ga- | rantis de la corruption d'une façon particulière. | Le tout rassemblé & arrangé, pendant une longue suite | d'années, avec beaucoup de peines & à grand fraix, | par | A. VROEG. | Collection qu'on offre aux Amateurs entière & à | un prix raisonnable, jusqu'au 22 Septembre de | cette année; après l'Echéance duquel ter- | me, elle sera vendue aux plus offrands, | le 6 Octobre 1764. à la Haye, | Dans la Maison de Mr Coster, au coin du Veene- | straat sur le petit Marché aux Herbes, | par | Pierre van Os, | Libraire demeurant sur la Place à la Haye. 1764. | Ou l'on distribue ce Catalogue.

Title also in Dutch. Preface in Dutch and reprinted in French, pp. I–XVI. List of items, as "Naamlyst der Vogelen, | Meestendeels, geschikt naar het stelsel van | der Heer Linnæus." Pp. 1–33; "Gekorve of beenderlooze Dieren." Pp. 34–49. Followed by "Adumbratiunculæ" pp. 1–7, as follows:

ADUMBRATIUNCULÆ

Avium variarum præcedenti Elencho insertarum, sed quæ in Systemate Naturæ Illustr. Linnæi nondum extant.

N. 8 FALCO (*epicyanus,*) cera pedibusque flavis, corpore supra plumbeo, subtus albo ferrugineoque squamato, cauda aequali fasciis obscuris. Magnitudo Tinnunculi. [Woont hier.[1]]

N. 18 LANIUS (*ruficeps,*) supra fuscus, vertice rufo, fronte fasciaque oculari nigris, subtus macula alarum, rectriceque utrinque extima tota albis. Magnitudo Collurionis, cujus secundum *Brissonium* mas est. [Woont hier.]

N. 28 PSITTACUS (*caudacutus,*) totus viridis, subtus flavescens, remigibus introrsum fuscis, cauda brevi cuneata acuta. Magnitudo Passeris; rostrum pedesque flavescunt. [Surinam.]

N. 43 CUCULUS (*serratirostris,*) rostro serrato. *Trogon* Brisson. Spec. 1–3. Edwards similem rostro avem in novissimo Volumine pinxit. Brissonii prima species femina, tertia varietas secundæ suæ videtur esse. [Surinam.[2]]

N. 54 ALCEDO (*ænea*) atroviridis, subtus ferruginea, fascia transversa jugulari viridi-atra, albo variegata, abdomine albo. Magn. vix Spinum æquat. Remiges omnes interiori margine albæ,

[1] These notes in brackets are taken from the "Catalogue."

[2] Described in the "Catalogue" as follows:

"43. Koekkoek, het Mannetje. (Serratirostris, Mas.) De onderbek van deze soort is aan merkelijk, heed vier tanden welke zaagsgewys naar vooren overhellende geschikt zyn. Het hoofd en de Borst zyn paars glanzig, het lijf en de staart van boven is koper glanzig van kleur."

secundariæ exteriori albo passim interruptæ.
[Surinam.]

N. 55 Alcedo (*cristata.*) colores fere nostratis, qua longe minor; pennæ verticis elongatæ, transversim fusco variæ. [Cabo de goede Hoop.]

N. 59 Certhia (*Virescens*) brachiura viridis, subtus flavescens, lineolis cœruleis longitudinalibus. Forte junior avis tertiæ speciei Linnæi.
[Surinam.]

N. 59* Certhia (*collaris*) fusca, viridi inaurata, subtus cinerea, fascia pectorali transversa rubra. Ad speciem Brissonii 20. pertinere videtur. [*Not* in "Catalogue," and locality unknown.]

A N. 60

[end of p. 1.]

N. 60 Trochilus (*guainumbi*) curvirostris, viridis sericeus, remigibus atris, rectricibus lateralibus apice albidis. [Cabo de goede Hoop.[1]]

N. 62 Fringilla (*erythrina*) variabilis, supra fusco-cinerea, punctis alarum miliaribus albis sparsis, subtus rubro-variegata. Hæc innumeris colorum varietatibus ludit. Rostrum constanter rubrum & puncta miliaria alba, utut sæpe perpauca, in alis semper adsunt. Ad *Amandavam* Linnæi forte referenda. [Woonplaats is de Kaap.]

N. 78 Columba (*cristata*) cœrulescens, capitis crista maxima compressa diffusa cirrhosa. Magn. supra Phasianum. Rostrum columbinum. Corpus plumbeo cœrulescens antrorsum dilutius. Fascia nigra a rostro ducta, oculos includens. Irides fulvæ. Dorsum medium humerique tinctura transversa punicea, antice abrupte terminata, postice obsolescente. Tectrices secundariæ albæ, extremitate puniceonigræ. Cauda plumbeo-fusca, apicibus rectricum dilutioribus. *Phasianus cristatus* Brissonii Spec. 6. [Banda.]

N. 99 Turdus (*puniceus*) corpore purpureo, alis caudaque discoloribus. Femina forte haec est, alarum pennis fuscis, uti & cauda. In simillima alia ave,

[1] Called "Bloemzuigertje Ronkertje of Kolibrit" in the "Catalogue."

quæ mas videtur, alarum remiges primarias albas extimas apice nigricantes, tectricesque secundi ordinis elongatas, carinatasque observavimus. Brissonio utraque avis *Cotingis* annumeratur, quorum 5. & 6. speciem efficit. Quem hic marem innuimus Edwardi Tab. 341. exhibet. [Zuyd America.]

N. 100 TURDUS (*minor*) flavescente fuscus, subtus sordide albus, cauda rotundata. Minor turdis nostratibus reliquis, canorus, in arundinetis habitans. Rostrum nigricat , mandibula versus basin flava. Gula alba. Cetera subtus albus, lutescente sordidus. Supra cinereo fuscus, versus caudam lutescens. Remiges fuscæ, pedesque. Nomen Belgicum a clamore fortitur. [Europe.]

N. 113 LOXIA (*tricolor*) rubra, facie abdomineque atris, alis gryseis. Fringilla major. Præter faciem, & abdomen a jugulo ad anum, atra, coccinea. Alæ vero gryseofuscescentes. Rostrum nigrum. Pedes grysei. [Kaap.]

N. 114 & 115. LANIUS (*Carbo*) ater, capite rubente, maxil-

[end of p. 2.]

maxilla inferiore basi aucta. Hab. in America meridionali. Rostrum & habitus fer Lanii; max. superior ad apicem vix emarginata, inferior basi tumescens & fere usque ad oculos cornea, convexiuscula. Corpus totum brunneo atrum, velut holosericeum. Caput vero & collum jugulumque, supra atrum, purpurascunt seu cupreorubent. Cauda longiuscula rotundata atra. Remiges fuscidiores. In *Femina* dorsum quoque rubro perfusum. Magn. infra Collurionem. Edwards tab. 267. [Referred to as *Lanius purpureus* in the " Catalogue ", with locality " Surinam."]

N. 142 FRINGILLA (*Citrinella*) flava, supra cinerascens, artubus nigricantibus. Caput, cervix cinerea; dorsum & frons cinereo-flavescunt. Subtus, urrhopygiumque flavissimus. Remiges tec-

tricesque nigræ; remiges limbo exteriori, secundariæque tectrices apice flavæ. Cauda bifurca; rectrices flavæ, exteriori limbo flavescentes, interiori albidæ. Rara avis.
[Hier in het Duin gevangen.]

N. 143 FRINGILLA (*undulata*) cauda cuneiformi, fascia oculari rostroque rubris, corpore undulato supra fusco, subtus cinereo rubescente. Edwards 179. [Kaap.]

N. 144 FRINGILLA (*macroura*) supra nigra, macula humerali subtusque alba, rectricibus quatuor intermediis longissimis, lateralibus interius oblique albis. Magnitudo Spini. [Oostindie.[1]]

N. 145 PARUS (*cyanochlorus*) supra cœruleo ater, subtus frontemque flavus, remigibus rectricibusque tribus lateralibus, interiori latere, partim albis. Hic-casu collocatus, ad Paros brachyuros pertinet, Manacos Brissonio dictos.
[Surinam.]

N. 156 MOTACILLA (*hypoleuca*) fusca subtus alba, remigibus intimis, rectricibusque tribus lateralibus exterius albis. Magn. fere Lusciniæ. Supra nigro fusca femina, mas nigrior. Frons prima, subtusque tota alba. Remiges 2, tectricesque intimæ maximam partem albæ. Rectrices utrinque 3. exterius longitudinaliter versus basin albæ. [Hier.]

N. 168 MOTACILLA (*striata*) supra cinerea, subtus alba, capite colloque fusco striatis, pennis fuscis. Magn. Phœnicuri. Rostrum nigricat. Cauda æqualis, cinerascens. Remiges interio-

A 2 res

[end of p. 3.]

res limbo exteriori pallido, omnes cauda nigriores. Caput antici, collumque subtus prae-

[1] Described in the "Catalogue" as follows:

"144. Weetwtje (Macroura). By Johnston Tab. 35. Word het zelve Sperling genaamed. 't Heest de grootte van een canarie, boven op de staart leggen vier veeren ter lengte van 10 duim."

ter gulam, & pectoris pars lineolis longitudinalibus. Cantu excellit. [Valt hier.[1]]

N. 169 MOTACILLA (*plumbea*) dorso fusco testaceoque vario, capite colloque canis, cauda cinerea. Magn. fere Phœnicuri. Caput, collum totum & pectus medium cano-plumbea, abdomen albidum; latera, dorsumque testaceorufa, plumis medio fuscis; remiges quoque exteriori margine rufescentes. Urrhopygium caudaque cinereofusca. Rostrum basi flavescens. [Valt hier.[2]]

N. 175 PARUS proprie est, a num. 145. eo diversus, quod gula collique pars subtus quoque atra, remiges interius limbo tantum versus basin albæ, & ipse mole inferior sit.
[Referred to as *Parus aureus* in "Catalogue," with locality "Surinam."]

N. 177 MOTACILLA (*cantillans*) supra plumbeocinerea, subtus testacea, pennis fuscis, rectrice utrinque extima exterius alba. Magnitudo Hipolaidis. Oculi circulo cincti rufo in utroque sexu. Supra obscure plumbeo cinerea; subtus rufa, abdomine albo. Linea maxillaris utrinque alba obsoleta mari. Alæ fuscæ, limbis pennarum grysescentibus. Cauda rotundata alis nigrior, rectrice utrinque extima exterius alba. Pedes flavi. Rostrum basi flavum. Femina multo obscurior sordidiorque coloribus. [Uit Italie.]

N. 179 Est Varietas *Cantillantis,* supra cinerea, in capite plumbeo cana; subtus alba, in pectore sordida & velut russulo tincta. Alis tamen, rostro, pedibus, cauda simillima Italicis. [Valt hier.]

N. 222 MELEAGRIS (*mitrata,*) galea rubra, appendiculis rictus oris subulatis. Similis *Galeatæ* seu vulgaris, qua paulo minor. Capitis, cum colli initio subpiloso nudi, vertex totus & cera, in qua nares, rubra. Verticis tuber conoïdeum compressum reclinatum. Appendiculæ ad oris angulos lineares, apice rubræ. Plica gulæ longitudinalis. Corpus nigricans; colli ima pars lineolis transversis, reliquæ plumæ guttis miliaribus,

[1] Called "Hofzanger, Basterd Nagtegaal" in "Catalogue."
[2] Called "Blaauwe boere Nagtegaal" in "Catalogue."

in remigibus caudaque seriatis, albis, variegata. Rostrum corneoflavescens, pedesque. [Madagascar.]

N. 223 MELEAGRIS (*cristata,*) capite nudo, crista verticis reflexa atra. Magn. Meleagridis mitratæ.

[end of p. 4.]

tratæ. Caput collique prior pars cute-atra nuda. Gula subpilosa. Vertex topho plumarum reflexarum atro ornatus. Appendiculæ circa os nullæ. Cera flavescens. Ima colli pars plumis atris vestita. Corporis plumæ ubique punctis, quam in vulgari specie, minutioribus, cœruleo albis, sparsæ. Remiges primariæ fusco nigræ, secundariæ punctis, uti corpus, verum seriatis, in exteriori vexillo in continuas lineas coalitis; extima secundariarum margine exteriori alba. rectrices caudæ rotundatæ breves atræ. Pedes nigri. [Oostindie.]

N. 244 ANAS (*dorsata*) alba, prora, alis caudaque nigris, dorso undulato. Magn. Boschadis. Marina. Caput, collumque cum trunci initio atra; caput virore fulgidum. Alæ-nigræ, macula alba. Dorsum album, lineolis undulatis transversis. Urrhopygium & subcaudales atra; rectrices fusconigræ. Irides flavæ. Rostrum pedesque nigricant. [Noord Zee.]

N. 245 ANAS (*albifrons,*) forte præcedentis femina, Irides flavæ. Caput ferrugineo-atrum, levi cupreo nitore, collum versus truncum sensim obsoletius ferrugineo-fuscum. Dorsum, subcaudales, lateraque fusca, albo-undulata. Urrhopygium caudaque fusca, alæ nigriores, macula alba; Synciput circa basin rostri album, quo maxime a præcedenti distinguitur. Rariosima hæc est, cum prior sæpius in vivariis & fera visatur.

[Hier in het Westland.]

N. 248 ANAS (*adunca*) Linn. sp. 35. Fera hæc est. Tota atra, subtus, pennasque fuscida, capite, collo, urhopygio viridi nitentibus. Remiges 5 extimæ albæ. Remigum secundariarum exteriores, apice, exterius albomarginatæ, longitudinaliterque nigriores & subchalybeæ. Macula ovalis gulæ alba. Irides fulvæ. Rectrices intermediæ apice recurvæ. Ab hac rarissima specie, in fluminibus passim habitante, varietas *Domesticæ,* quæ adunco rostro est, originem traxisse videtur.

[Verscheide Europische Rivieren.]

N. 358 [258] ANAS (*ferruginea*) ferruginea, remigibus caudaque atris, tectricibus secundariis albis. Magn. fere Anseris. Rostrum anatino minus & angustius, ut pedes, nigrum. Corpus totum ferrugi-

A 3 neum

[end of p. 5.]

neum in pectore & sub cauda dilutius. Caput quibusdam, cum collo, cano-cinereum plerumque concolorum. Remiges atræ; secundariarum pleræque exterius viridi sericeæ, intimæ ferrugineæ. Tectrices secundariæ albæ, maculam magnam efficiunt. Urhopygium supra atrum, lateribus fuscum griseoque undulatum, utet femora. Cauda subæqualis atra.

[No locality cited, but called " Tartarysche Gans, *Anser Tataricus ferrugineus Mas*" in Catalogue.]

N. 271 STERNA (*albifrons*) alba, cauda forcipata, vertice nigro, triangulo frontali albo; remigibus extimis nigris. Turdum mole æquat. Alba, in dorso cana. Vertex & cervix atra, sed triangulum album, apice rostro insistens, in fronte. Remiges 2 extimæ fusconigræ, interiori margine albæ; reliquæ exterius, loco nigri, canæ. Tectricum extimæ binæ fuscæ. Cauda hirundinacea, alba. Rostrum pedesque flavescunt; apex rostri & ungues nigricant.

[Maassche Land.]

N. 281 COLYMBUS (*ruficollis,*) fuscus, collo subtus rufo. Magn. infra Alcam Allen. Totus fuscus, subtus albicante nebulosus. Collum totum subtus late ferrugineo-rufum in Mare; in femina obsoletius, eique gula albo fuscoque nebulosa, &

truncus subtus medio albo argenteus. Rostrum nigrum, basi subtus oblique flavum.
[Is the female of 280, which is called "*ruficollis,*" "zeer zeldzaam in onze Meiren."]

N. 279 COLYMBUS (*fuscus*), fuscus, subtus albo-argenteus, iridibus fulvis. Magn. Alcæ Alle. Supra ferrugineo fuscus. Remiges secundariæ interius albæ. Subtus gula, mediumque trunci alba, reliqua fusco sordida. Rostrum flavescens, supra fuscum. [Alle binne Wateren in Holland.]

N. 301 SCOLOPAX (*testacea*) rostro subarcuato, corpore fusco gryseo vario, subtus testaceoalbo, urrhopygio albo. Magn. Canuti. Plumæ supra fuscæ, in dorso medio nigræ, apice utrinque gryseo, in quibusdam, prope nigredinem, testaceo accedente. Subtus plumæ, usque adalvum albam, testaceæ, extremo albæ; basis caudæ alba, punctis sagittatis nigris. Remiges fuscæ, secundariæ, tectricesque apice albicantes. Rectrices obsolete fuscæ marginibus albicantes. Rostrum subarcuatum laeve, pedesque alba.
[Hier op't Eyland Blankenburg gevangen.]

N. 306 SCOLOPAX (*erythropus*) pedibus rubris, corpore supra fusco, subtus albo, alis caudaque variega-

[end of p. 6.]

variegatis. Magn. Pluvialis. Rostrum læve, extremo clementer arcuatum, nigrum. Mas supra fuscus, femina magis cano-plumbea; fascia utrinque a rostro supra oculos alba. Mas subtus albus, cinereo nebulosus & versus postica fasciato-undulatus; femina alba, collo substriato. Remiges & tectrices primariæ nigricant; reliquæ, tectricesque harum margine utroque fasciolis abbreviatis albis. Cauda subæqualis urrhopygiumque fasciolis albis transversis. Pedes rubri, unguibus nigris. [Valt hier.]

N. 311 TRYNGA (*ralloides*) supra fusca, subtus alba, remigibus secundariis aliquot albis. Magn. Hiaticulæ. Supra fuscocinerea, capite cerviceque obsoletioribus & substriatis. Subtus alba, sed collum propre pectus cinerascens. Remiges nigricantes, primariarum interiores secundariæque margine albæ, harumque binæ fere totæ. Cauda subacuta, rectricibus mediis nigricantibus, lateralibus cinereis, sensim albicantioribus. Rostrum apice crassiusculum, pedesque nigra. [Vallen hier op onze stranden.]

N. 320 TRYNGA (*alba*) alba, supra canescens, remigibus nigricantibus, interius albis. Trynga proprie est, non Charadrius. Supra collique lateribus incana, rhachibus nigricantibus. Magn. Canuti. Remiges nigricant, interne albæ & primariarum aliquot interiores exterius quoque; tectrices secundariæ apice albæ. Humeri fusci. Cauda inæqualis, rectricibus 2. mediis longioribus, omnibus fusco canescentibus. [Valt aan de Noordsche Zeekusten.]

FINIS.

[end of p. 7.]

NOTES ON THE BIRDS DESCRIBED BY PALLAS IN THE "ADUMBRATIUNCULA" OF VROEG'S CATALOGUE

By CHARLES W. RICHMOND

The *Catalogue* of Adrian Vroeg's collection, which was brought to light by Mr. Sherborn during his work on the *Index Animalium*, is one of the rarest of ornithological tracts, only one copy being known to exist. Unlike A. A. H. Lichtenstein's *Catalogus Rerum* (of which two copies are known), Vroeg's *Catalogue* appears to have been entirely unknown to bibliographers, and Mr. Sherborn has wisely decided to place on record the new matter contained in it by offering a careful reprint of the "Adumbratiuncula." This separately-paged portion of the *Catalogue* contains descriptions of thirty-eight species, thirty-five of which were supposed to be additional to the tenth edition of the *Systema Naturæ*. Although his name does not appear in connection with it, the "Adumbratiuncula" was written by Peter Simon Pallas, as he tells us in his *Zoographia Rosso-Asiatica* (II, p. 199), a statement long anticipated by Linnæus in the 1766 edition of the *Systema Naturæ*, where "*Pallas. adumbr.*" is quoted in the synonymy of several species.

In view of the importance of this first effort by Pallas, it seems desirable to follow Mr. Sherborn's reprint with a list of modern determinations of the new names contained in it. An attempt to supply such a list is offered herewith.[1]

No. 8. *Falco epicyanus* PALLAS.

This is *Falco nisus* LINNÆUS, 1758. Male adult.

Accipiter nisus (LINNÆUS).

No. 18. *Lanius ruficeps* PALLAS.

Unquestionably the Woodchat Shrike, *Lanius senator* LINNÆUS, 1758 (*L. auriculatus* MÜLLER, 1776; *L. pomeranus* SPARRMAN, 1786). *L. senator* is based on Albin (Nat. Hist. Birds, II, p. 15, pl. 16), who describes and figures this species from a specimen without locality. Grant (Nov. Zool., IX, p. 464) gives "Germany" as the type locality, but Albin refers only incidentally to a second individual from Germany.

Lanius senator LINNÆUS.

[1] The correct names of the various species are given in heavy type.

No. 28. *Psittacus caudacutus* PALLAS.

Almost certainly *Psittacus jugularis* MÜLLER, 1776 (*P. tovi* GMELIN, 1788), but no mention is made of the orange spot on chin; and Surinam, if the locality is correctly given, is beyond the present known range of the species. The expression "remigibus introrsum fuscis" probably relates to the inner wing-coverts, which are conspicuously brown in this species.

?**Brotogeris jugularis** (MÜLLER).

No. 43. *Cuculus serratirostris* PALLAS.

Some species of *Trogon,* probably *Trogon viridis* LINNÆUS.

No. 54. *Alcedo ænea* PALLAS.

Clearly *A. superciliosa* LINNÆUS, 1766.

Ceryle ænea (PALLAS).

No. 55. *Alcedo cristata* PALLAS.

The locality cited for this species is "Cabo de goede Hoop," and the species commonly known as *Corythornis cyanostigma* (RÜPPELL) is abundant there. The adult has a coral red bill, but younger birds have this member nearly black, as in the common Kingfisher of Europe. No mention is made of the color of the bill in the description, but the statement "colores fere nostratis" would indicate that Pallas had a black-billed specimen before him. If the locality were in doubt we might be justified in synonymizing Pallas' bird with the black-billed Madagascar species (*Alcedo cristata* LINNÆUS, 1766), but under the circumstances it seems best to adopt **Corythornis cristata** (PALLAS) for the South African bird and **C. vintsioides** (EYDOUX and GERVAIS) for that of Madagascar.

No. 59. *Certhia virescens* PALLAS.

This is *Certhia cærulea* LINNÆUS, 1758; female or young.

Cyanerpes cæruleus (LINNÆUS).

No. 59*. *Certhia collaris* PALLAS.

This is probably *Certhia chalybea* LINNÆUS, 1766 (not *C. chalybeata* LINNÆUS, 1764), but the yellow pectoral tufts and the narrow blue line separating the green throat from the crimson band across the chest are not mentioned in the description. Nor is the color of the throat specifically mentioned.

Brisson's species no. 20 (with which Pallas compared it) is *C. chalybea.*

?**Cinnyris collaris** (PALLAS).

No. 60. *Trochilus guainumbi* PALLAS.

This is evidently a hummingbird and not a sunbird. The locality is wrong and should probably be "Surinam." The description agrees very closely with the species now called *Polytmus thaumantias* (LINNÆUS, 1766).

No. 62. *Fringilla erythrina* PALLAS.

The description indicates the winter plumage of the male of *Fringilla amandava* LINNÆUS, 1758. The locality cited is wrong.

Sporæginthus amandava (LINNÆUS).

No. 78. *Columba cristata* PALLAS.

Columba coronata LINNÆUS, 1766; this name is based partly on "*Pall. adumb.* 78."

Goura cristata (PALLAS).

No. 99. *Turdus puniceus* PALLAS.

Ampelis pompadora LINNÆUS, 1766. The first reference cited by Linnæus in the synonymy of this species is "Turdus puniceus. *Pallas. adumbr.* 99."

Xipholena punicea (PALLAS).

No. 100. *Turdus minor* PALLAS.

Turdus arundinaceus LINNÆUS, 1758. *T. minor* is cited by Linnæus (ed. 12, p. 296) as a synonym of *T. arundinaceus,* and Pallas gives it as a reference under *T. junco* (= *T. arundinaceus*).[1]

Acrocephalus arundinaceus (LINNÆUS).

No. 113. *Loxia tricolor* PALLAS.

Emberiza orix LINNÆUS, 1758.

Pyromelana orix (LINNÆUS).

Nos. 114, 115. *Lanius carbo* PALLAS.

This is the same as *Tanagra jacapa* LINNÆUS, 1766, and "Lanius Carbo. *Pallas. adumbr.* 114" is one of the references quoted by Linnæus in the synonymy of the species (cf. Syst. Nat., ed. 12, p. 314).

Ramphocelus carbo (PALLAS).

No. 142. *Fringilla citrinella* PALLAS.

Apparently *Fringilla citrinella* LINNÆUS, 1766, in winter plumage. If so, no change in name will be required.

?**Spinus citrinella** (PALLAS).

[1] *Zoographia Rosso-Asiatica,* I, p. 458.

No. 143. *Fringilla undulata* PALLAS.

Equals *Loxia astrild* LINNÆUS, 1758, and is so quoted in the synonymy of that species in the twelfth edition of the "Systema Naturæ."

Estrilda astrild (LINNÆUS).

No. 144. *Fringilla macroura* PALLAS.

Undoubtedly the same as *Emberiza serena* LINNÆUS, 1766 (= *E. principalis* of the same author), but the locality "Oostindie" is wrong. Pallas does not allude to the black patches on the sides of the chest, nor to the white on the rump and hind neck, but otherwise his diagnosis is very good. Brisson, on whose "petite Veuve" Linnæus based the name *E. serena,* describes the bird as having only two elongated tail-feathers, and the crown as rufous.

Vidua macroura (PALLAS).

No. 145. *Parus cyanochlorus* PALLAS.

Easily referable to *Fringilla violacea* LINNÆUS, 1758.

Euphonia violacea (LINNÆUS).

No. 156. *Motacilla hypoleuca* PALLAS.

This is *Muscicapa atricapilla* LINNÆUS, 1766, which Mr. Oberholser finds is the same as *Motacilla ficedula* Linnæus, 1758.

Ficedula ficedula (LINNÆUS).

No. 168. *Motacilla striata* PALLAS.

The description agrees very well with *Muscicapa grisola* LINNÆUS, 1766, but the statement "cantu excellit" is at variance with the accounts given by Dresser and other recent authors.

Muscicapa striata (PALLAS).

No. 169. *Motacilla plumbea* PALLAS.

Doubtless *Motacilla modularis* LINNÆUS, 1758, but the description fails to mention the conspicuous brown white-striped patch on the ear-coverts.

Accentor modularis (LINNÆUS).

No. 175. *Parus aureus* PALLAS.

This is *Tanagra chlorotica* LINNÆUS, 1766.

Euphonia aurea (PALLAS).

No. 177. *Motacilla cantillans* PALLAS.

Without doubt the Dartford Warbler (*Sylvia undata* BODDAERT, 1783).

Melizophilus cantillans (PALLAS).

No. 179. "Variety" of No. 177.
This is referred to *Motacilla sylvia* LINNÆUS, by Pallas, in his Zoographia Rosso-Asiatica, I, p. 488.

No. 222. *Meleagris mitrata* PALLAS.
Pallas here uses Mœhring's generic term *Meleagris* for the Guinea fowls. *Numida* of Linnæus dates from the "Mus. Adolph. Frid.," 1764, p. 27, which was not published at the time Pallas wrote.
The present species was later described in detail and figured by the same author (Spic. Zool., I, fasc. IV, 1767, p. 18, pl. 3), under the name *Numida mitrata*.
Numida mitrata (PALLAS).

No. 223. *Meleagris cristata* PALLAS.
Better known as *Numida cristata* Pallas, 1767. The locality "Oostindie" is wrong, as the species is restricted to west Africa.
Guttera cristata (PALLAS).

No. 244. *Anas dorsata* PALLAS.

No. 245. *Anas albifrons* PALLAS.
Both this and the preceding are quoted as synonyms of *Anas marila* LINNÆUS, 1766 (= *A. marila* BRÜNNICH, 1764, which has precedence over Pallas).
Fuligula marila (BRÜNNICH).

No. 248. *Anas adunca* LINNÆUS.
Domestic variety of *Anas boschas* LINNÆUS.

No. 358 [= 258]. *Anas ferruginea* PALLAS.
Anas casarca LINNÆUS, 1768. So identified by Pallas (Zoogr. Rosso-Asiat., II, p. 242).
Casarca ferruginea (PALLAS).

No. 271. *Sterna albifrons* PALLAS.
According to Pallas (Zoogr. Rosso-Asiat., II, p. 336) this is *Sterna minuta* LINNÆUS, 1766.
Sterna albifrons PALLAS.

No. 281. *Colymbus ruficollis* PALLAS.

No. 279. *Colymbus fuscus* PALLAS.
Both refer to the Little Grebe (*Colymbus fluviatilis* TUNSTALL, 1771).
Colymbus ruficollis PALLAS.

No. 301. *Scolopax testacea* PALLAS.
Pallas later synonymizes this with *Scolopax lapponica* LINNÆUS, 1758 (cf. Zoogr. Rosso-Asiat., II, p. 180).
Limosa lapponica (LINNÆUS).

No. 306. *Scolopax erythropus* PALLAS.

This is the Spotted Redshank (*Scolopax fuscus* LINNÆUS, 1766; nec *S. fuscus* LINNÆUS, 1758, = *Tantalus fuscus*, 1766, = *Guara rubra*).

Totanus erythropus (PALLAS).

No. 311. *Trynga ralloides* PALLAS.

Tringa hypoleucos LINNÆUS, 1758, according to Pallas (Zoogr. Rosso-Asiat., II, p. 196).

Actitis hypoleucos (LINNÆUS).

No. 320. *Trynga alba* PALLAS.

The description agrees minutely with the Sanderling (*Tringa arenaria* LINNÆUS, 1766) in autumn plumage.

Calidris alba (PALLAS).

THE SCULPIN AND ITS HABITS

By THEODORE GILL

I

One of the commonest and most characteristic groups of fishes of all the cold northern waters is that represented by the common Sculpin of the New England coast. In no American work is there a full account of its habits. To fill this gap as much as possible, in the present state of our knowledge, is the object of the present article. The data are derived mainly from F. A. Smitt's *Scandinavian Fishes,* and works or memoirs by McIntosh, Masterman, Thomas Scott, Nordquist, Ehrenbaum, and the earlier ones of Fabricius, Van Beneden, Day, and A. Agassiz, in addition to personal observations in the field along the New England coast, Grand Manan, and Newfoundland, and in the aquarium. The language of the authors from whom information is derived is given as far as possible. The illustrations have been copied chiefly from the excellent contribution of Doctor Ehrenbaum.

II

The Sculpins of the American shore-men are representatives of a family rich in genera and species known as the *Cottidæ,* or, as angli-

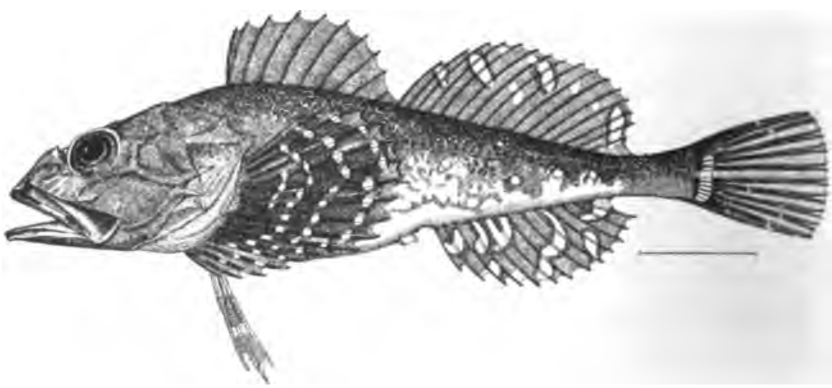


FIG. 45.—Common Sculpin (*Myoxocephalus scorpius*). After Jordan and Evermann.

cized, *Cottids.* The *Cottids* or *Sculpins* are elongated mail-cheeked fishes, contracted backward from the pectoral region, or long-conic, but more or less swollen about the abdomen; the skin of most is naked, but in some incompletely scaled; the pectorals have expanded bases which curve forward and downward, and in one form (*Synchirus*) are even connected below, and the ventrals are imperfect, having a spine (closely joined to the next ray) and two to four (exceptionally five) simple rays.

The most distinctive characters, however, are furnished by the skeleton and especially by the shoulder girdle. The two bones, hypercoracoid and hypocoracoid, which in most mail-cheeked fishes, as in others, intervene between the great shoulder bone and the four bones at the base of the pectoral fin, are in the Cottids so reduced and shoved out of place that the middle at least of the basal bones (actinosts) connect with the great shoulder bone.

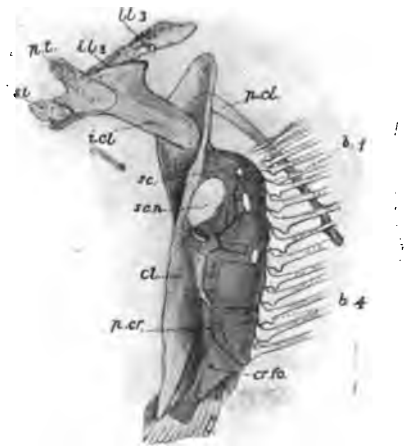


FIG. 46.—Shoulder girdle of the Sculpin (after Parker), showing the intervention of the second and third actinosts between the first and fourth actinosts (*b.* 1 and *b.* 4) and the hypercoracoid (*sc*) and hypocoracoid (*cr*). *b.* brachials or actinosts; *cl.* clavicle; *cr. f.* coracoid (hypocoracoid) foramen; *i. cl.* interclavicle; *ll.* 2, 3, lateral line scutes; *p. cl.* postclavicle; *p. cr.* produced coracoid (hypocoracoid); *pt.* posttemporal; *sc.* scapula (hypercoracoid); *sc. n.* scapular notch; *st.* supratemporal.

FIG. 47.—Skull of Sculpin (after Girard).

Other important osteological characters are coincident with these and manifest in modifications of the vertebræ, relations of the ribs, and structure of the skull.

Most of the salt-water Cottids (Myxocephalines) have large branchial apertures and narrow isthmus or none at all; the skull also differs notably from the fresh-water forms, the hinder portion being oblong and semi-oval and gradually contracted into the moderately narrow interorbital area. The armature of the head is much more fully developed than that of the fresh-water species, as may be inferred from the specific name (*18-spinosus* or 18-spined) of the most common kind found along the coasts of middle and southern United States.

FIG. 48.—Skull of Sculpin (after Girard).

The genus *Myoxocephalus* is the largest of the marine genera of the family and comprises the species best known, at least to the dwellers around the northern Atlantic. Its principal distinctive characteristics are the naked body, wide gill-apertures and freedom of the gill-membranes below, the development on each side of three preopercular spines (the uppermost of which is straight and the lowermost turned downward), the presence of a single suprascapular spine, the projection of the upper jaw beyond the lower, and the absence of palatine teeth.

FIG. 49.—Skull of Miller's-thumb (after Girard).

The name by which the common species, as well as others of the genus, is almost universally known along the entire coast of America is Sculpin, or Skulpin. The etymology of this word is generally indicated as unknown or doubtful. It has even been suggested that it was derived from skull and pin, the latter with the sense of spine, but, while quite apt and plausible, such a formation is not in accordance with verbal development. It is probably, if not certainly, a derivative of the old Latin *Scorpæna* and *Scorpio,* and cognate with the modern modifications, amongst which is the French as well as the English *Scorpion. Scorpion* is still one of the names for it in France, although according to Moreau, one in more frequent use by the fishermen is *Diable de mer* or Sea Devil. *Scorpion* or *Sea Scorpion* is also applied to it in England. Now, the word *Sculpin* is employed in England for a Callionymid or Dragonet. At one time, however, it must have been used for Cottids, inasmuch as, besides its general use in North America, the name was taken to Barbados and aptly given to a near relative (*Scorpæna plumieri*) of the *Scorpæna* of the ancients and the modern inhabitants of the bor-

FIG. 50.—Skull of fresh-water Miller's-thumb.

ders of the Mediterranean. It is also in limited use in California for another species of *Scorpæna* (*S. guttata*).

In England, *Sculpin* is not recorded as a name of this fish, its principal vernacular names there being *Sea-scorpion* and *Sting-fish; Gundie* and *Sutor* are Scotch names. A distantly related species (*M. bubalis*) is called in England *Father-lasher* and in Scotland *Lucky-proach.*

III

The most common and longest known of the species is the *Myxocephalus scorpio* of the North Atlantic. This is distinguished from its fellows by the moderate uppermost preopercular spine (which is about as long as the diameter of the eye and only about twice as long as the one next below), and the number of fin rays (generally D. X, 17; A. 14).

The sexes are strongly differentiated from each other when mature and especially during the breeding season; so trenchantly, indeed, that it was long before they were considered to belong to the same species, and fishermen even, notably in Sweden, " regard them as two distinct kinds of fishes."

The male has more developed fins, i. e., higher dorsal and anal and longer pectoral and ventral, and the pectoral and ventral are muricated on their inner surfaces, a variable number of pectoral rays (from the fifth to the eleventh) being studded inside with minute spinous tubercles. The colors are bright and the belly is reddish or copper-colored and diversified with large, pure white spots, and the ventrals are white, banded with blackish or red on the rays.

The female has lower and shorter fins, i. e., comparatively low dorsal and anal and shorter pectoral and ventral fins, and the last are smooth on their inner surfaces. The lateral tubercles of the body are also sparse or almost wanting, thus contrasting with the many of the male. The colors are dull, the belly being dirty yellow and the ventral are also yellow, but banded with black.

Such are the typical characteristics, but there is much independent variation with age and condition in the species.

There is considerable variation in size, and, if the Greenland form is considered conspecific, it is remarkable. Its size may be said to increase roughly with the latitude. The Arctic or Greenland Sculpin is claimed sometimes to attain a length of more than three or even six feet.[1] The usual size of the Sea Scorpion in Scandinavian waters is

[1] Day, in *The Fishes of Great Britain* (1, 45), asserts that "the largest variety (*C. Grœnlandicus*) is reputed to attain to 6 feet in length." I know of no authority for such a statement and doubt whether the fish ever grows much or any more than 3 feet long.

between eight and ten inches, and in British waters it may reach sexual maturity when four inches long. The American form, along the New England and British colonial coast, is about as large as the Scandinavian fish.

IV

The species is one of the most abundant of fishes in the high northern seas. It enters most harbors and numbers may at almost any time during the summer be caught from the wharves. It is, Smitt declares, "one of those that may be called migratory," inasmuch as it "moves from one place to another along the coast of the sea which it inhabits, occurring in considerable quantities at a certain spot for some years and then suddenly diminishing in number, not to reappear in any abundance until after the lapse of ten or twenty years."

It is most abundant "in water of no great depth, where the bottom consists of clay or stones overgrown with seaweed," but is by no means confined to such places and may be found almost anywhere, and at considerable depths.

It is an unsocial fish and lives alone most of its life, although generally not far from its fellows.[1] That life is spent mostly near or on the bottom and its sluggishness is rarely relieved except when hunger is to be satisfied. According to Smitt, it often "passes the hours of daylight in dark crevices, awaiting the approach of some victim," but, on the other hand, it may be sometimes seen in high latitudes (as around Newfoundland and Grand Manan) in shallow water when the sun, in unclouded splendor, is at the zenith.[2] When impelled to move, "its movements in the water are speedy but not prolonged, and the winding curves," somewhat "like those of an Eel, in which the body moves, are apparently the result of considerable exertion. The great size of its fins does not contribute greatly to the speed of its movements, but seems rather intended to maintain the equilibrium of its bulky and unwieldy body." Otherwise it is so apathetic and "its timidity is so slight that, when touched, it only makes a leisurely movement to avoid the object that has disturbed it, and soon stops, as still as if nothing had happened." This apathy or want of sensitiveness sometimes astonishes a captor. "When drawn out of the water, it wriggles a few times in its efforts to get

[1] This statement is to contrast the species with schooling fishes.

[2] In a couple of hours before noon on a bright July day the writer caught 16 Sculpins from a small wharf in Grand Manan and found 10 females and 6 males; the collective sexual differences were for the first time pointed out in the *Proc. Acad. Nat. Sci. Phila.*, 1872, pp. 213, 214.

free, and, not succeeding in this, seems quite indifferent to its fate, seldom showing any marked sign of life, even though it is still alive." It is, however, "not remarkably tenacious of life."

The large open mouth betokens voracity, and appearances are not deceptive. "Rashness and voracity," declares Smitt, are among the "chief traits of its character. In the latter respect it is surpassed by few if any fishes. Three Roach, each nearly 100 mm. long, have been found in a Sea-Scorpion 220 mm. in length." The main food supply is derived from "other fishes, though, especially in winter, when the supply of fish is scanty, it does not despise crustaceans, worms and mollusks." In fact it is omnivorous, and "it always pays more attention to the quantity than to the quality of its food."

Such were the observations recorded by Smitt, but Thomas Scott (1902) and Van Beneden (1871) found chiefly crustaceans in the stomachs of those examined by themselves. Van Beneden found only a small Gurnard in one, but "otherwise the food consisted entirely of crustaceans," while Scott found that, "in the stomachs of seven specimens, all from the Bay of Nigg, near Aberdeen, the food observed consisted altogether of crustacea, and included larval Decapods, the fragments of a Hermit Crab, *Porcellana longicornis, Idothea baltica,* the *Cypris* stage of *Balanus,*" etc. In fact the food apparently depends very much on what the omnivorous fish can secure. Inasmuch as the Sculpin is a sluggish animal, it is natural that crabs and the like should be found more frequently than more active creatures. It is remarkable, however, that mollusks and worms should rarely be found. To that extent it appears to show preference, for such can generally be easily secured by a fish.

Observations of American Sculpins have confirmed those of the European fishes. Girard (1850) "examined the contents of the stomach of many marine and fresh-water Cottoids and in the *Acanthocotti*" or Sculpins "of the Boston Bay found them to consist of crabs" (*Panopeus herbstii*). Linton (1901) found "annelids, copepods, shrimps, and young fish in the alimentary canals of young specimens" of the Little Sculpin (*M. æneus*) and "many young flounders and shrimps" were "taken from alimentary tracts of young Sculpin from Katama Bay, April 28, 1900."

It is not entirely voiceless, for, when taken in the hand, it is apt to utter a grumbling or rather gurgling sound, or cry, and hence has been named in some places Grumbler or Growler (Grogneur) and Sea-Cock (Coq de mer).

These sounds were fully studied by Dufossé many years ago and the results published (1874) in an elaborate memoir (Ann. Sc. Nat.

Zool., (5,) xx, 91–103). He thought that if we pronounce in a subdued voice the diphthongs *ou! vous! ous!* as short consonant sounds, we may produce sounds which have a great analogy with the most common cries of the Sculpins. Their utterances are so instantaneous that we cannot observe the pitch. They are emitted at irregular intervals and with considerable irregularity in intensity and variations of timbre; their resemblance to the cries of several toad-like Batrachians is remarkable and they might easily be mistaken for such. On account of this similarity Dufossé designated their sounds as cries (*cris*) to distinguish them from those of other fishes.

The sounds are produced in water as well as in the open air and are the results of the vibratory contraction of some of the muscles round the mouth of the fish; especially those of the floor of the mouth and those connected with the branchial and hyoid apparatus. These muscles, Dufossé urges, are subject to the will of the fish and the sounds they cause are consequently voluntary. Furthermore, the buccal and respiratory cavities, when dilated, become capable of re-enforcing all the sonorous vibrations, like a resonant cavity on a musical instrument. The branchiostegal membrane becomes puffed out and gives the fish the appearance familiar to salt-water anglers and watermen.

V

The relations of the sexes to each other, and the armature of the inside surfaces of the pectorals and ventrals of the males, had long ago led some naturalists to infer that perhaps the males had connection with the females, but most had discredited the suggestion. McIntosh and Masterman indeed, in 1897, had urged " that it is evident that " the eggs " are not fertilized before deposition." Nevertheless, a year later, (in 1898,) Nordquist claimed that the eggs are so fertilized. The importance and interest of the alleged discovery entitles him to tell the story in his own way. His short article was published in the *Meddelanden* of the Societas pro Fauna et Flora Fennica (pt. 26, 1899–1900, pp. 31–32). It is here translated:

"When, on the 27th of last November [1898], I cut open some Sea-Scorpions from the neighborhood of Helsingfors for the purpose of determining the spawning time of this species, I found some eggs in the ovary of one of the individuals examined, near the genital aperture, which were considerably bigger than the rest and of a paler color. On looking more closely at one of the eggs, I found that it contained a rather far advanced embryo with two distinct pigmented eyes. On closer examination of the ovary, I could discover, here and there, several similar eggs at an advanced stage of development. An examination of several individuals gave a similar result. In all were found some eggs in the ovaries bigger than the others, and paler in color (a few were as clear as water) and containing a distinct embryo which was not, however, in every case as fully developed as in the first mentioned eggs.

"Here then, for the first time, was certain evidence that in the Sea-Scorpions the spawn becomes fecundated while yet in the ovary, a condition known to exist only in a few exceptional cases in the class of fishes, as in the Sharks, the *Embiotocidæ* of the Pacific Ocean, several *Scorpænidæ* and some *Blenniidæ*, among others *Zoarces viviparus*, which also occurs on our coasts."

Viviparity is much more common among fishes than Nordquist was aware of. His observation, however, was of great interest. The facts in the case would at first seem to imply that internal fertilization takes place, but is speedily followed by oviposition and the subsequent assumption of care of the eggs by the male. But soon afterward, Nordquist's conclusion was called in question. E. Ehrenbaum, in the *Wissenschaftliche Meeresuntersuchungen* (Neue Folge, VI, Heft 2, Apr. 15, 1904, pp. 133–134) published the results of new studies of the same subject and his remarks are here translated:

"The conspicuous enlargement of the anal papilla in *Cottus scorpius* during the spawning-time suggests the question as to the occurrence of internal fecundation in that species. Nordquist (*Meddel. Societ. Fauna et Flora fenn.*, p. 26, 1900), confirming an earlier observation made by Ekstrom (*Die Fische in den Scheeren von Mörkö*, p. 176, 1835), did indeed find far advanced embryos with distinctly visible dark eyes in the ovary of mature females, so that consequently copulation must have taken place previously. In opposition to this McIntosh (*Fourteenth Ann. Rept. Fish. Board f. Scotld.*, pt. III, p. 181) has positively denied that such a condition could be admitted for the *Cottus* of the British coasts; and also in the German North-Sea I have found no support whatever for the assumption of internal fecundation. I have never found embryonate eggs in the ovary and have on the other hand in nature found recently deposited eggs at very early stages of development. I have also noted that the eggs deposited in the aquarium, which continued to develop normally and emitted larvæ subsequently, were completely undeveloped when dropped, and presented after twenty-four hours early stages of furrowing. Internal fecundation with following embryonic development within the maternal organism can therefore not be considered the rule. Agreeing with this, Nordquist has lately communicated to me, by letter, that he has also changed his view in the meantime; that internal fecundation does occur in *Cottus scorpius* (and *quadricornis*), but only *as an exception,* and that the isolated fecundated eggs in the ovary generally develop abnormally and probably die in the ovary. But the occurrence of internal fecundation even as an abnormality must be considered for the present as restricted to the extreme northeastern Baltic. But this very circumstance increases the interest of Nordquist's observation, as accordingly the northern *Cottus* appears as a transitional link with his Arctic relatives, such as *Gymnocanthus*.

Cottunculus, Centridermichthys, Triglops, and others, which all possess highly developed anal papillæ, and in which therefore copulation and internal fecundation of the female is probably the rule."

A legitimate inference from the facts so offered seems to be that when the sexual products are fully ripe, the sexes may come together and the ova are fertilized just before or during protrusion, but sometimes there may be some arrest or retardation in passage of the eggs and then there may be internal fertilization. The subject is certainly worthy of study by some one favorably situated for making the necessary observations and the data here given bring the literature up to date.

VI

About the beginning or middle of winter, or, it may be, not before the beginning of spring, most of the adult Sculpins are ready to discharge their ripe eggs. They seek fitting places to deposit their burdens and generally discharge their eggs in masses which are "at first quite soft, though cohering together by a secretion," but "soon harden, the capsules adhering by facets to each other as in the Lumpsucker, so that the egg-mass resembles a spongy structure into which water freely enters, and is retained in considerable quantity, even though the eggs are uncovered by the tide, a provision of some importance." These egg-masses are extruded "in the sand or pools in the rocks," or attached to stones, tangle roots, sea-weed and, "indeed, almost anything convenient." If, perchance, discarded "old shoes" or "tin vessels" be lying around, they are apt to be utilized as nesting places. (See plate XLIX, I.)

A ripe female, "isolated in a glass vessel" at St. Andrews, was observed by McIntosh and Masterman. "This specimen, whose abdomen was distended," had been "observed to be somewhat restless the previous day, and on the first of March it rested quietly on the bottom of the vessel, and in a few seconds deposited a mass (as large as a duck egg) of faintly pinkish eggs, keeping its breast-fins in active motion during the process, and then it dashed through the water, sending some of the eggs over the edge of the vessel."

In a state of nature, the males are said to generally select the places for deposit severally, and "to make a nest of sea-weeds and pebbles for the reception of the spawn." The male also continues to keep watch over the deposit and may even brood over them, clasping the egg-mass with his pectoral and ventral fins, whose inner surfaces are provided with asperities or hooks which enable him to obtain a firmer hold of the mass. Doubtless, however, he often releases his

1. NEST OR EGG-MASS OF THE SCULPIN (AFTER EHRENBAUM)

2. MALE SCULPIN OVER EGG-MASS (AFTER EHRENBAUM)

hold and fans the eggs to secure aerification. Ehrenbaum has given a characteristic illustration (see plate XLIX, 2).

The extruded eggs vary from pink "to roseate, orange, straw-color, and deep red." Their diameter ranges from 1.5 to 2 millimeters. "The capsule is thick, tough, and resistant, and shows the facets or processes by which it adheres to surrounding eggs; it appears minutely punctured, under a high power, the punctures having as a rule, a more regular (linear) arrangement than in the Lumpsucker." The yolk has a variable number of oil-globules which ultimately coalesce into a single large one. The development depends on temperature and two or three months may elapse before any eggs are hatched.

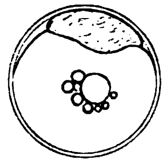


FIG. 51.—Sculpin egg developing (after Ehrenbaum).

VII

The newly hatched larva is about a third of an inch (about 8 millimeters) long. "The yolk forms a comparatively small prominence ventrally, and the large oil-globule lies at its front inferiorly"; "the mouth is open, but the lower jaw is at first immovable." In about two days after hatching articulation for the jaw supervenes. The larvæ are soon carried to the surface of the water and "swarms" may be "occasionally captured in the surface tow-nets, as in the Forth" in Scotland in March and April. When six days old, the young fishes are about eight or nine millimeters long and "the yolk has diminished, while the oil-globule has been elevated to the gullet."

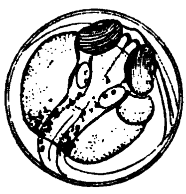


FIG. 52.—Sculpin egg with larva (after Ehrenbaum).

For some time the growth of the young is slow and the length may even diminish in the course of losing its larval and assuming its post-larval condition. "On the seventh day" McIntosh found that they measured only "7.7" millimeters long and "during the two or three subsequent days the pigment made great progress." One, a

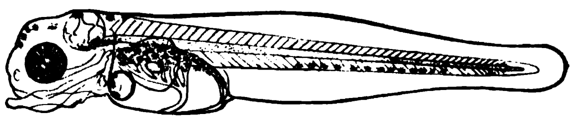


FIG. 53.—Sculpin larva just hatched (after Ehrenbaum).

month old, figured by Ehrenbaum, was about ⅖ of an inch (10 millimeters) long and still preserved the completely rayless and undivided fin membrane, but membranous pectorals had been de-

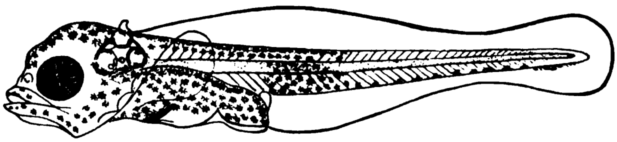


FIG. 54.—Sculpin larva four weeks old (after Ehrenbaum).

veloped (although no ventrals), pigmentation had farther advanced. the jaws had become better marked and prominent, and even the position of the future occipital spines was indicated. At a still more advanced stage, when about ¾ of an inch (18 millimeters) long, the fins had become differentiated and their rays partially developed, ventrals also had appeared, the head was well outlined, and even the

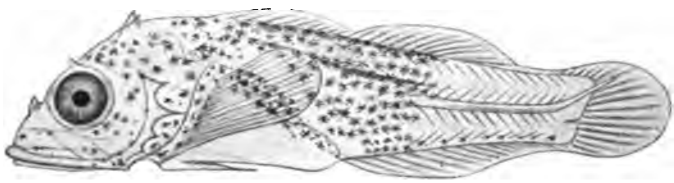


FIG. 55.—Young Sculpin, 18 mm. long (after Ehrenbaum).

spines had become manifest. In fine, a recognizable cottid was to be seen. McIntosh found some in June about an inch long, "with adult characters" and well developed rays. At such a stage the ground is resorted to. Growth continues; on the first anniversary they range from about a little more than two to three inches (57 to 75 millimeters) in length; on the second nearly four inches. Some may be sexually mature at that age; for a female, not quite four inches (98 millimeters) long, observed by McIntosh, "had almost ripe eggs," but most of them do not begin to propagate till they are about six inches long.

VIII

The Sculpin has little economical importance among the nations of Europe or in America. According to Day, it is "not used" in Britain; according to Moreau it is considered of no use in France. In Scandinavia, we learn from Smitt, "it is only the female . . . that is used for food by the poor, who prove the truth of the proverb: 'The Sculpin is the best of fishes when there is no other to be got.' If carefully prepared, the flesh is eatable, but it always retains a rank flavour which is repulsive to most people. The liver, however, is one of the island delicacies, but if eaten in any quantity its flavour is also unpleasant. The male is considered poisonous by most of the islanders, and is therefore not eaten."

REPORT ON THE CONSTRUCTION OF A VOWEL ORGAN[1]

By E. W. SCRIPTURE

The attempt to construct an organ that could sing the vowels took its rise in connection with work on curves of speech and experiments in the production of artificial vowels. The Helmholtz theory that the physiological action in the vowels consists in reinforcing overtones of the glottal vibration was rejected because it had been proved to be incorrect by the results of analyses of vowel curves by Professor Hermann of Königsberg, and myself. Work was begun on the Willis-Hermann theory, namely, that a vowel consists of a resonance tone aroused by a series of sharp puffs from the glottis. The action of the glottis in producing sharp puffs and not smooth vibrations was supposed to be similar to that of striking musical reeds. The reed portion of a vox humana pipe was accordingly placed in connection with a bellows.

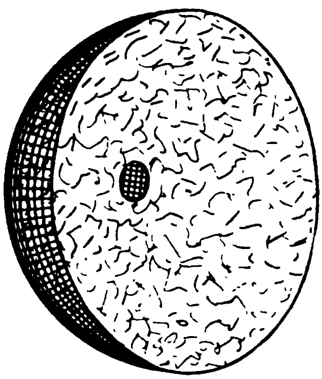


FIG. 56.—Wire frame with cotton for half of spherical water resonator.

A previous investigation had made it evident that a hitherto neglected factor must be introduced into any vowel theory, namely, the softness of the wall of the resonator. A reed pipe will respond only when the pipe cavity is harmonic to the reed; the vocal cavities would respond only to overtones of the glottal tone—if they were made of metal. The walls of the cavities are, however, soft and inelastic; it was necessary, therefore, to imitate this property. Water resonators were first used. To obtain spherical water resonators, wooden forms were made into which wire netting was pressed; the resulting series of pairs of wire hemispheres were lined with absorbent cotton (figure 56). For use the resonators were dipped in water; the cotton had

[1] This is the first report submitted by Professor Scripture on the results of his experiments on the subject indicated in the title. The researches were conducted under the auspices of the Smithsonian Institution, by the aid of a grant from the Hodgkins Fund.

absolutely no acoustic effect and the resonators were in fact hollow spheres of water. A more convenient form is the cubical water resonator built on a wire cube (figure 57).

These resonators were placed in succession above the reed with the result that a harsh *u* as *oo* in *boot* or *a* as in *father* could be obtained.

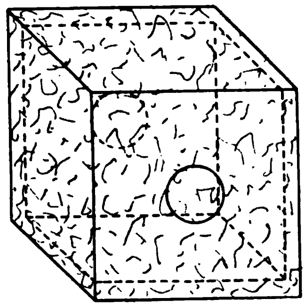


FIG. 57.—Wire frame with cotton for cubic water resonator, or with flesh.

The next step was to remove the harshness. This was accomplished by trying reeds of various kinds—mahogany, ebony, oak, cedar, hard rubber, celluloid, etc. With an ebony reed a pure and beautifully musical *u* and *a* could be obtained.

This result, however, was entirely independent of the size and character of the resonators: a large resonator or a small one would alike give *u* when nearly closed, and *a* when further opened; the different resonators merely changed the shading of the vowels a trifle.

These experiments indicated the inadequacy of the Hermann vowel theory. The possibility of the Lloyd theory was considered. According to this theory the vowel character is due to the relation between two tones independent of their pitch; for example, *i* as in *machine* would be heard if two resonance tones were produced in the relation of 1:37, *a* if in the relation 1:5, and *u* if only one were present, no matter how high or low the tones might be. Accordingly the resonators were tried in pairs, then in threes and fours; the result was the same, always *u* or *a*.

The experiments were then repeated with hollow spheres of gelatine, modeling wax, and putty, with cavities cut out of different vegetables and fruit, etc. The results remained essentially the same.

These experiments showed that some factor in vowel production must have been entirely overlooked. Since the fact of the softness of the vocal resonators had been overlooked by all previous investigators, it was natural to conclude that some other factor in the vocal cavities had not been considered. It was therefore decided to imitate as closely as possible the structure of the cavities above the larynx. A human skull was fitted with gelatine cheeks and other parts to replace the flesh. The lower jaw received a gelatine casting that filled the base of the mouth and represented the tongue; a series of such castings was made with the tongue in different positions. The result was the same as before.

It was now evident that the theory was defective in regard to the glottal tone itself. The first supposition was that the glottal tone might not be independent, but might change its character with every vowel. The glottal lips are soft tissues; might they not change the manner of vibration according to the resonance of the cavities around them? The reed was discarded and experiments were now made with rubber membranes held in wooden frames. Circular, square, and triangular openings (figures 58, 59, 60) were covered with

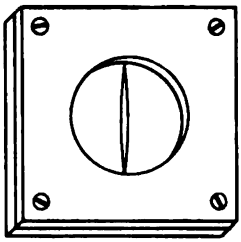


Fig. 58.—Circular rubber glottis.

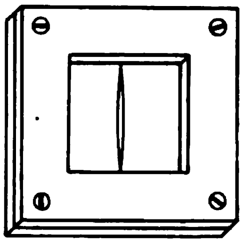


Fig. 59.—Square rubber glottis.

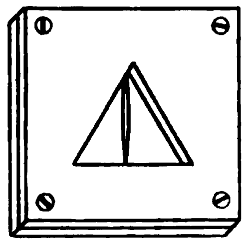


Fig. 60.—Triangular rubber glottis.

rubber membranes held at any desired tension; the air pressure caused the edges of the slit in the middle to vibrate. Such a membrane may vibrate on each side as a whole, or with any number of nodal lines concentric to the slit. The timbre of the tone of the membrane depends on its manner of vibration. Resonators of wood (hard walls) were introduced at this point, as the water and gelatine resonators were inconvenient for manipulation. These resonators could be used singly, doubly, triply, etc.; the rubber glottis could be introduced directly above the blast or between two resonators. The experiments were entirely successful. By proper combinations of two resonators of different sizes with the rubber glottis between them, all the vowels could be produced. Any change in the size of one of the resonators resulted in a slightly different shading of the vowel tone.

It was possible to look into the opening of the upper resonator and see the rubber glottis. Its manner of vibration could be seen to be different for different resonators. These experiments are a substantiation of the view that the action of the human glottis differs with different vowels; the reason, however, is, in my opinion, a different one for the human glottis. The glottal lips are not thin membranes like rubber, but masses of flesh; there is little possibility of their changing their vibrations in response to the reaction of the cavities around them. In my opinion the fibers of the *M. vocalis* which compose the lips, contract differently for each vowel, and therefore produce differences in tension throughout the mass; the slant fibers to the *Ligamentum vocale* can also create longitudinal nodes. My view is that the sound of each vowel is associated with certain sets of innervations to the fibers of the *M. vocalis* as well as with certain innervations of the muscles of the vocal cavities; these innervations differ for each vowel; the vowel is therefore formed at the glottis as well as in the mouth. This view, developed in the work for the Smithsonian Institution, was thereafter adopted as the basis of my work on speech curves for the Carnegie Institution; in many cases the curves became for the first time intelligible.

Although the change of the action with the rubber glottis has not the same cause as with the human glottis, the vowels produced were sufficiently good to make it advisable to keep to the principle of construction. The work was continued with them. To soften the tone, wooden resonators were tried with linings of butter, lard, etc. Tones of human softness could be obtained by felt-lined resonators.

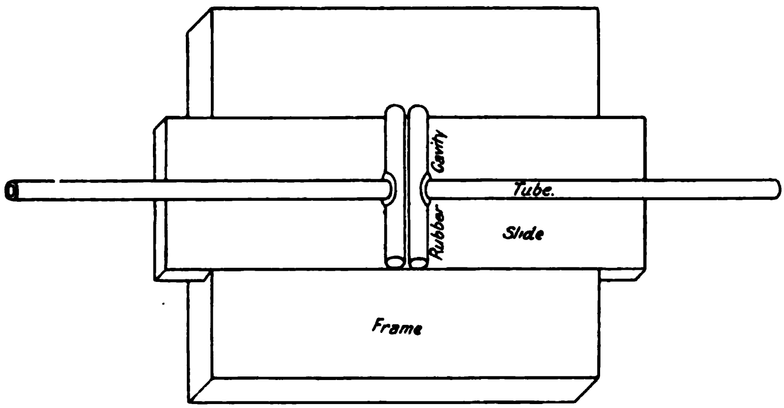


FIG. 61.—Adjustable rubber glottis.

In spite of a specially constructed metal holder for the rubber membranes, it was found impossible to tune them; moreover, they constantly got out of order. Work is now going on with a glottis of the form shown in figure 61. The wooden frame fits between two resonators. Each slide carries across its edge a tube-like cavity of very thin rubber. When the slides are pushed together the two rubber cavities touch with any desired closeness. The tension of the rubber cavity is regulated by blowing into and closing a supply tube above the slide.

With the felt-lined resonators in combinations of twos and threes, it is possible to imitate all the vowels and their variations. The problem at present consists in replacing the rubber glottis by something which changes its form of vibration for different vowels, but which can be accurately tuned and does not alter with time. When this can be done, a complete organ can be built that will sing the vowels, or a vowel register can be added to a regular organ. Eight vowels would be enough for most purposes; for a single octave with chromatic intervals, 124 vowel pipes would be needed. A vowel register of this size could be effectively used in church music.

A TREE COVERED WITH THE NESTS AND WEBS OF SOCIAL SPIDERS (PORTRAIT OF MR JAMBUNATHAN)

THE HABITS AND LIFE HISTORY OF A SOCIAL SPIDER (STEGODYPHUS SARASINORUM KARSCH)

By N. S. JAMBUNATHAN

Of the many creatures that attract attention, one of the most common is the spider. Every hedge-row glistens with the snares so cunningly laid by these little hunters. They are found everywhere, and no place is too sacred for their occupation. The walls you lean against, the corners you look into, the books you begin to dust, the grassy lawns over whose soft beds you delight to walk, and even the flowers whose fragrance you enjoy, contain the spiders peculiar to each of these localities. Some there are that run, that spin, that dive, some that even dig to catch their prey—thus pursuing several of the various crafts and industries of men,—spinning, weaving, diving, and mining. Some spiders seem to be successful aeronauts performing long journeys across mountains, rivers, gulfs, and seas—by means of their slender threads. These facts and many others concerning their extraordinary habits and intelligence have already been noted by man.

Simon, a French arachnologist, first hazarded the statement that some spiders exhibit a form of social living. This assertion I find questioned by that eminent American entomologist, the Reverend Doctor McCook, who maintains " that all spiders are solitary in their habits and that the discovery of a social species, if confirmed, would be most important. Males and females might be seen living amicably together for a considerable period, but this cannot be social living" (vide *Scientific American*, page 186, September 17, 1892).

From this we may easily see that the question as to the existence of communal spiders is a debated one. My study of social insects generally led me to a closer investigation of the habits of the spiders of southern India, and in March, 1898, I discovered at Saidapet, Madras, a group which I believe may properly be termed " social spiders."

These spiders live in a sponge-like nest of ramified net-work of inter-communicative canals with a number of outside openings. The nests, often seen attached to the ends of the branches of trees or to leaves of the prickly pear, are ash-gray in color and made of dried leaves and refuse matter from their food, and are over-lined with their thick, sticky threads, thus affording an advantageous background for the spiders, for being of the same color as the nests they are thus given necessary protection. Numbers of sheet-like webs radiate from the nest, in one or many directions. At a given spot five or six nests are often found built over the leaves of the prickly pear, with a number of connecting webs—thus establishing means of inter-communication. These hanging webs are peculiarly constructed. A number of strong and non-sticky threads are irregularly laid to form the warp while the woof of sticky threads closely laid in a zig-zag manner, connect the non-sticky threads issuing in all directions, sometimes establishing communication between one nest and another, like bridges to cross the intervening space.

The number of spiders in a nest varies from 40 to 100. Males and females occupy the same nest in the proportion of 7 to 1, though sometimes the females are less numerous.

The creature itself is not less interesting than its nest. It is more or less a compact animal about the size of our ordinary vagrant spider of the family Attidæ.

THE FEMALE

	Millimeters.
Total length cephalic thorax and abdomen	8
Abdomen	4
Cephalothorax	4

THE MALE

Total length	6
Abdomen	3
Cephalothorax	3

This spider belongs to the family Eresidæ. It is ash-colored, this tint being due to the color of the hairs over its body surface. Three longitudinal white stripes mark the dorsal surface of the abdomen. The limbs are striped gray and brown. A number of dark lines makes the abdomen appear segmented, but closer examination shows them to be only external figurations. There are approximately six pairs of dots arranged on either side of the leaf-like patch on its dorsal surface.

The ventral surface of the abdomen bears two black irregular spaces, the lower one of which contains the spinnerets, which are six in number, with a cribellum. The cephalothorax is ash-colored with an anterior prominence that forms the head. The cephalic groove which is well marked in most spiders is absent here. The eight eyes are arranged in three rows as in Lycosidæ. The first two rows, of four and two, lie in a black spot in front of the head, while the other rows are a little behind with their faces directed rather towards the sides of the animal. Thus the spider can see objects in front as well as at the sides. The falces are black, pointing downwards, with the curved claws working sidewise.

In almost everything except in size and palpal organs, the male resembles the female, and although the male is the smaller, the measurements of the two do not show him to be the dwarfed individual found in many species of spiders. In place of the black streaks and stripes of the female, we meet with brown ones in the male.

As already mentioned, the prickly pear bushes appear to be the favorite resort of these spiders, though sometimes the branches of some other thorny plants are preferred. A whole tree may be so covered with the nests, that the leaves are hardly visible. I have also found these nests on tops of hills. If built on the prickly pear, the leaves serve as bases or floorings. If on the ends of branches of trees, the leaves serve as partition walls or roofs for their silken dwelling, which is plastered and cemented by means of woven threads. In every case the refuse of their food serves as a convenient substance for thickening the walls of their nest.

The web is arranged in longitudinal and zig-zag lines. If it is to be a horizontal sheet, a main line is made of the finest, strongest, yellowish silk-like threads with a lustre all their own. This main line is laid by the joint labor of six or seven spiders moving over the line a number of times, thus thickening it, and making it not one thread but a bundle of threads. Other lines are laid, connecting with this main line in all directions. These may be of fewer threads, yet strong enough for their purpose. Having now finished the warp lines of the web, the process of regular weaving is begun. The spiders settling at different places begin to spin out their thick, smoke-like, sticky threads and to lay them as connecting lines for their web. The method of drawing out the thread is unique in the spider world. In almost all the web-builders the sticky threads as well as the non-sticky ones come out as the spider moves from one line to another, a method which may not be possible here, these spiders using their hind pair of legs, which are then seen moving in quick succession rubbing against the spinnerets. The threads so taken are laid without any regard to either precision or symmetry, the only object being somehow to fill the space and make a net. These transverse sticky lines, being eminently elastic, can be drawn out to ten times their ordinary length. While there is work to be done, there is no standing still, no idleness; each individual appears to recognize its own responsibility in assisting to complete the web. As soon as a spider finishes work in one spot, it hastens on to where the web is still incomplete, so that within two or three hours the whole task is finished. This done, the spiders retire to the nest to enjoy a well-merited rest. Like some other spiders, these are also nocturnal in their habits and begin web-building between the hours of six and seven in the evening, finishing their toil before eight or nine.

The manner of repairing the nest is also very interesting. The first spider that comes out of the nest after sunset sets to work to repair any damaged portion it may discover. It thus never becomes necessary to completely rebuild their webs. The burden of building and repairing the webs falls heavily upon the females of this spider colony. They are the active workers. The males appear to do very little, though not wanting in apparatus necessary for web-building, since they may be observed, while young, actively participating in such a task. When they attain maturity, they think of nothing but courtship and love, and can then be seen moving about in the web, disturbing the females that are patiently engaged in their work.

With their nests and webs in shady places our spiders never suffer from want of food. Bees and mosquitoes, crickets and beetles, butterflies and moths in their pleasant flights entangle themselves in the waiting snares. The struggle of the victims sounds the signal that prey is available and the spiders hurry to the spot to pull and drag the victim to the nest. In this effort part of the web may be damaged. Spiders there are, in the family of Epeiridæ, that can skillfully disentangle a prisoner and carry it away without damage to their webs, but social spiders do not possess this skill.

The arrival of the victim is eagerly awaited by the spiders in the nest, ready to catch hold of some portion of the prey. Those carrying the precious booty never appear to resent the actions of others that pull the victim in all directions, before they finally settle down to partake of the food thus secured. Sometimes the spiders do not bring the victim to the nest but begin eating it where caught. On one occasion an extreme case of selfishness came under my notice. A spider pulled hard at a victim, got a good piece of its leg, and ran away to a corner to feed unobserved by the others. But as a general rule they are seen partaking of the meal at a common table and nothing can be more curious than the sight of these spiders, almost one over another sitting at dinner, some feasting at the head, some at the body, some near the tail-end, others sucking their repast from the limbs of the victim. To test their intelligence I once threw a big ant into a web. As the ant struggled a spider issued from the nest in the direction of the prey but found the creature too defiant to be easily pulled home. The spider caught one leg many a time, and many a time it ran for life, fearing the ant's bite. In a moment, another spider came to its aid, but, curiously enough, instead of catching hold of the ant, began to pull the first spider by its abdomen, until other spiders came to the rescue and the victim was carried away by their joint labor, to the common nest.

If such an ant were thrown into the web of an Epeiridæ, the victim, however big and ferocious, would be carefully bound by threads and thus secured. The social spiders know how to drag, pull and bite, but have never learned the finer and safer method of binding and securing their prey. Perhaps the extremely sticky character of the webs lessens the necessity for them to develop these finer methods.

In the foregoing paragraphs, two facts have been clearly recorded about the habits of this group of spiders, (1) the joint action and willing coöperation of a number of them to achieve a definite end, (2) the partaking by any and every spider that happens to get near it of the meal brought by one or more, the captors showing apparently no resentment. These two facts together with what has been noted in connection with web-building point to the conclusion that the spiders we are considering, certainly exhibit a form of social living which is, so far as I am aware, rarely met with in the spider world.

It has been noted by every arachnologist that the relation between the sexes in this group is something unique in spider communities. The male is generally a dwarfed individual, and is able to carry on his life's task only by agility and cunning. Such antagonism exists between the sexes, that a male seldom returns from courtship without losing a leg or two. It is a struggle which often imperils even his life. In some families, as in the Epeiridæ, this struggle has been so severe and lengthened that there have come to be certain profound modifications in the mental as well as the bodily structure of the males, they being often dirty colored and dwarfed individuals, and hardly recognizable as spiders at all. In addition to this the male is sometimes caught and devoured by his savage consort.

But the picture is not all dark—all tragic. There are some families that exhibit a more genial relationship. In the Attidæ, Lycosidæ, Thomisidæ, Phalangidæ, Tetragnathidæ, and Mygalidæ, the males are nearly as bright colored and attain to almost the same size as the females. Here there is no danger to life, all the risk that a male runs being, perhaps, the loss of a limb or two. In everyone of the groups of spiders mentioned, the female and male may be seen near each other only during the pairing season and even then the male has to make its own arrangement for food.

Here the absence of much disparity in size and color between the sexes, the friendly and communal living of the males and females in the same nest, and lastly, the happy and almost affectionate relation that subsists between the sexes, indicate a high order of development. The savage nature of the female in other groups is never displayed by the female spiders of this group.

The female gladly welcomes her lover and the male may be seen rubbing its pedipalps alternately against the genital pore of the female, sometimes for over three or five minutes. At other times one may find the male running after the other sex, in fact, hunting it through all the winding passages in the nest. The female may step aside, or run, and thus avoid the approach of the male, if she has no liking for such a meeting; but never does she exhibit the rancor and resentment with extended forelegs and well-drawn falces, found among the females of the family Epeiridæ.

The eggs when laid are packed in silk in a lenticular cocoon, which is white in color, and about six millimeters in diameter. Unlike the other spiders that carry the cocoon, either by means of their falces or spinnerets, the female in the group we are considering, attaches it to the side walls of the nest.

After a period varying from thirteen to fifteen days, the young ones try to emerge from the cocoon by tearing out portions of its walls. These little spiders, the size of an Indian mustard seed, move about and some of them settle over the back of the mother, after the manner of Lycosidæ. The abdomen of the young ones is globular and pink-colored. Until they pass through two or three moults, they do not appear to take any food. As they grow older, they partake of the food brought by the mother. I have often noted instances in which the females quietly retired, leaving the food they were eating to the young ones that clustered round it. After a few moults, the young spiders begin to participate, in their own little way, in the grand task of web-building. Small patch-works of webs, a few lines here and there, mark their juvenile efforts. At this stage no difference of size, color or sex is visible. The time required by the young spiderling to reach the adult condition, after issuing out of the egg, is almost three months.

While the development of the young is in progress, the adult members of the nest either desert it, one by one, to found, perhaps, new colonies elsewhere, or voluntarily starve themselves, or are starved to death by the rapacity and greed of the younger generation. In the nest at this stage I have found the young ones very active, while the members of the older generation were scarcely able to move. Later, I found only the dried remains of a few old ones to mark their former presence in the nest. Closer examination makes me strongly affirm that the dried remains are not the skins generally cast away after moulting, but the real bodies of the spiders shrunken and shrivelled up. In some nest I have also found one or two members of the older generation living with those of the younger generation.

Like other creatures, these spiders are subject to the varying influences of heat and cold, and show in some instances remarkable powers of adjustment. Living, as they do, in the tropics, they have learned a method of protecting themselves from heat by building their nests mostly under the shade of trees. If ever they happen to be exposed to the direct rays of the sun, as was a nest which I purposely tied to a hedge in my garden, the inmates are seen outside the nest resting on the threads proceeding downwards, the spiders being shaded by the nest. Evidently the heat between 11 a. m. and 4 p. m. in the interior of the nest must have been unbearable. Even when disturbed and driven within they would not remain inside the nest.

In winter the walls of the nest are thickened, especially in the upper part, which is exposed to the rainfall. The holes leading to the nest are to be found in the under surface, and those which might catch the wind are carefully closed. In spite of all these precautions, these creatures suffer like other animals during this season. They are able to protect themselves completely from neither wind nor rain, nor are they able to procure their food easily.

The area under my observation is limited to South India. So far as I have seen, and I have visited some of the typical districts—such as South and North Arcot, Salem, Coimbatore, Malabar, Chingleput, Madura, Trichinopoly and Tanjore—this species is more or less universally distributed throughout these districts. On the top of the Tripati hills, in North Arcot, at an elevation of some five hundred feet above the sea, I saw their nests. Considering the facilities these spiders have for safe and speedy dispersal, one need not wonder at their wide distribution. The young ones may sometimes be detected while on their aerial voyages to near or distant places as the winds permit. At other times one solitary spider, more or less in the adult condition, ventures out and settles near the mother colony. At times a female, while in the act of web-building, may be carried away by the wind and thus plant a new colony.

Before concluding this description let me rehearse the points which lead me to designate this group of spiders as social. We note the common nest for a number of spiders—males and females; the manner in which they build and repair their nests; their feeding together, and the absence of ill-feeling amongst them—these are characteristics not commonly met with among animals of the solitary kind. Other points in their habits go to strengthen my conclusion. The relation between the sexes is found to be one of affection, and the maternal feeling for the offspring verges almost on self-sacrifice.

While it must be conceded that these spiders have nothing of that differentiation and organization found in the communities of ants and bees, it still seems that the amicable existence led by them in the common which has been built by united effort, the friendly sharing of their meals, the more than toleration, the affection shown for each other by the male and female, and the self-denial of the mother on behalf of her young entitle this group of spiders to be called social.

APPENDIX.

The author, who has given such an interesting account of one social spider seems unaware of records of various other species. Probably all the species of *Stegodyphus* are social. The Rev. O. P. Cambridge was the first to record this habit in this genus, when describing *S. gregalis* from South Africa. A nest of this species was kept for some time in the London Zoölogical Garden. Mr. Marshall has written an account of this species which agrees very closely with that of Mr. Jambunathan. He notes that several feed upon the same insect, and that the old ones die in the early winter. He also speaks of a mouse that nests in the midst of a communal nest to feed on the insects, and of a Tineid moth that breeds in the débris of dead insects. Simon has described several social spiders from Venezuela, notable among them being *Uloborus republicanus.* Mr. Schwarz has found this species in Cuba, and notes that the males keep to one corner of the connected mass of webs.

References to the social spiders are as follows:

E. Holmberg—Anales di Agricolutura, II, 1874, p. 156.
C. Berg—Bol. Acad. Cordova, I, pp. 279–283, 1879.
O. P. Cambridge—Proc. Zoöl. Soc. London, 1889, pp. 42–44.
I. Bolivar—Bol. Soc. Espagn., XXI, p. 22, 1892.
E. Simon—Ann. Soc. Ent. France, 1891, pp. 1–14, 4 pls.
G. A. K. Marshall—Zoölogist (IV), vol. II, pp. 417–422, 1898.
L. Kathariner—Biol. Centrabl., XXI, pp. 72–74, 1901.
E. A. Schwarz—Proc. Ent. Soc. Wash., VI, pp. 147–148, 1904.

[N. BANKS.]

DESCRIPTION OF A NEW SYLVIETTA

By HARRY C. OBERHOLSER

A specimen of *Sylvietta rufescens* (Vieillot) from Damara Land, collected by Mr. C. J. Anderson, and now in the United States National Museum, differs so greatly from the Cape Colony bird that it appears to represent a well-marked subspecies which, as it seems to be undescribed, may be called:

SYLVIETTA RUFESCENS OCHROCARA subsp. nov.

Chars. subsp.—Similar to *Sylvietta rufescens rufescens,* but very much paler both above and below, the lores and postocular stripe pale brown instead of blackish; the rump and upper tail-coverts more tawny; the lower surface not so uniform.

Description.—Type, adult, No. 98,155, U. S. N. M.; Damara Land, western Africa, December 24, 1866; C. J. Anderson. Upper parts pale brownish gray—about the same shade as in *Sylvietta micrura*—the forehead rather paler and tinged with ochraceous buff, the lower rump and the upper tail-coverts dull pale tawny; tail light fuscous, narrowly margined and tipped with paler; wings fuscous like the tail, the superior coverts and the quills broadly edged externally with the color of the back, which color on the primaries and outer secondaries has distally a decided tinge of ochraceous, the quills with basal part of inner margins narrowly paler; superciliary stripe, cheeks, and auriculars dull ochraceous buff; lores and post-ocular stripe dull light brown; chin, upper throat, and middle of abdomen cream buff; sides of neck, jugulum, breast, sides, flanks, crissum, lining of wing, and thighs ochraceous buff, rather brighter on sides, flanks, and thighs. Length of wing, 62; tail, 27; exposed culmen, 13.5; tarsus, 19.5; middle toe, 11 mm.

Although in size this new form appears to be about the same as true *Sylvietta rufescens,* the color differences are quite sufficient to warrant specific separation were it not for the great probability that by continuity of range *ochrocara* is but a pale geographical race of *rufescens.*

The original description of *Sylvietta rufescens*[1] was based on the bird from Cape Colony, to which therefore the title *rufescens* should

[1] *Dicæum rufescens* Vieillot, Nouv. Dict. d'Hist. Nat., IX, 1817, p. 407.

be restricted. Neither of the two other synonyms of the species apply to the Damara Land race, for *Sylvietta crombec* Lafresnaye[1] has the same basis as *S. rufescens* (i. e., Levaillant), and *Oligura meridionalis* Bonaparte[2] from southern Africa is a *nomen nudum*.

[1] *Rev. Zool.*, 1839, p. 258.

[2] *Consp. Av.*, I, 1850, p. 257.

COYUNO RICE PLANTERS, PHILIPPINE ISLANDS

THE TUGDA, OR RICE PLANTER, OF THE COYUNOS, PHILIPPINE ISLANDS

By E. Y. MILLER

Those who easily associate the name of Richard I. Gatling with the rapid-firing gun have not all learned that he was also the inventor of the many-pointed seed-drill. Gatling was born on the shores of Albermarle sound, North Carolina, and in his early youth turned his attention to the improvement of things necessary to the daily occupations of the people there. Observing the wearisome method of planting rice, the man walking along a row in the field, dropping the grains through a small hole in the handle of a gourd, he set to work to devise a better way of doing it. He turned the gourd into a cylindrical sheet-iron drill-hoe, fastened a dozen of these in a frame, to which he added wheels, shafts for a mule, and a seat for the driver. By means of mechanical attachments to the wheels, the flow of seeds was regulated as the apparatus was driven along.

It was my pleasure to discover the most primitive forerunner of this device. Each separate shovel-point is worked by a man, as will be seen in plate LI. It is hollow, but no seed pipe runs through it. The women follow on after the separate drillers. In fact, Gatlin combines a twenty-man power and twenty-woman power Philippine agricultural operation into a single device.

The Coyunos occupy the little group of islands called the Cuyo archipelago, in the province of Calamianes, Philippine islands. According to A. Marche they appear to be Christianized Tagbanuas. This group of islands, where the *tugda* is used, is very much over-populated. All the available soil is under cultivation, so that there is no sod land. The *tugda* cannot be used in sod or soft ground. During the latter part of the dry season, April and May, the rice land is cleared of all vegetation by cutting the weeds and other plants close to the ground with a short working bolo. This vegetation is collected in piles and burned, leaving the ground bare and hard. No further cultivation is attempted. When the first rain comes, some time in June, the people gather in parties of ten to fifty to plant the rice. The men, each of whom is equipped with a *tugda,* will work in a line. The force of the fall of the *tugda* causes the point to enter the ground in a slanting direction to a depth of about one inch. The rebound occasioned by the spring in the crooked lower end causes the implement to jump upward, to clear itself of the hole made, to throw the dirt aside, and to move forward to make a new hole. These are about six inches apart. The women follow the men and drop a few grains of rice into each hole. The children come last, running about the field dragging branches of trees. This brushes the loose dirt back into the holes, covers the rice grains, and completes the planting. The work is enlivened by the clattering of the split tops of the *tugdas* and the shouts of the men. Very often the working crowd will be accompanied by musicians, who sing and play while the work is going on.

The structure of the *tugda* in detail will be seen by reference to plate LII and the description accompanying it. The stem of *tugda* measures 16 feet 1½ inches; the length of the point is 1 foot 9 inches.

Explanation of Plate LII

a. Lower, working part of the *tugda*. The natural bend of the bamboo stem at the bottom and the method of attaching the point are shown.

b, 1 and 2. Drill-point of tough bamboo, front and side views. The bands to prevent splitting are of rattan.

c, 1 and 2. Upper portion of the *tugda,* showing method of ornamentation and opening for sound holes. The braided band (2) was put on after the specimen was sawed in two for transportation. The *tugda* is made from a single stem.

d. Lower portion of decorated half. The decoration is from Spanish motives partly, but the etched rings are of native design.

e. Upper portion showing the split top forming the noisy clapper. The two halves fly apart and then together at every stroke on the ground.

STRUCTURE OF THE TUGDA IN DETAIL

FOSSIL PLANTS OF THE GROUP CYCADOFILICES

By DAVID WHITE

Introduction

The group of fossil plants appropriately designated the "Cycadofilices" embraces a number of Paleozoic generic types combining structural characters of the ferns and of the gymnosperms. As originally established by Potonie[1] it was confined chiefly to genera founded on petrified trunks, petioles, and roots, with the provisional reference of several frond types. Subsequent research has established the correlation of the fronds of several of the members, and recently two distinct types of seeds have been definitely identified with two of the Cycadofilic genera, while a third type of fruit has been found united with a genus of fronds not before suspected of belonging to the Cycadofilices. The fact of the discovery of the seeds has been brought to the attention of biologists in this country by several American paleobotanical writers[2] whose brief communications on the subject are confined largely to the nomenclatorial classification of the group, rather than to the characters of the latter. So far-reaching are the paleobotanical findings concerning the members of this group, and so important are they to all evolutionists, that it seems desirable to put American botanists in closer touch with the principal and very interesting features relating to these singular types which appear to stand intermediate to the ferns and the gymnosperms. To do this in brief form is the purpose of this paper.

The number of genera to be included in the Cycadofilices, or Pteridospermeæ, as designated by Oliver and Scott, is necessarily indefinite, since future discovery will doubtless bring to light characters causing the inclusion therein of other genera whose structure or fructification is at present unknown and whose systematic classification is therefore now provisional only. On the other hand, a more complete knowledge of the reproduction in some of the types now included may require their promotion to a higher, gymnospermic, rank. It must be remembered that some of the genera are

[1] *Lehrbuch der Pflanzenpaleontologie*, 1899, p. 160.

[2] Lester F. Ward in *Science*, July 1, 1904, p. 25; Aug. 26, p. 279. E. W. Berry in *Science*, July 8, 1904, p. 56; July 15, p. 86; J. M. Coulter in *Science*, July 29, 1904, p. 149.

known only by the anatomical structure of their stems and petioles; that fronds have been definitely correlated with but four generic types; and that fruits are known in but three. Concerning the microsporangiate organs, we have hardly more information than we have respecting the Cycadofilic fruits.

The group appears to have been confined to the upper Paleozoic, and almost exclusively to the Carboniferous, including, in a broad sense, the Permian. The widely diversified associated or contemporaneous ferns are overwhelmingly eusporangiate, most of them showing closer affinities with the Marattiaceæ than with any other living family, though imperfect rings of various forms several cells in width, or may be in thickness, characterize some of the rarer fern genera. The pteridophytic comparisons are therefore with the Marattiaceæ, the Ophioglossaceæ and, to a less extent, with the Osmundaceæ and the Lygodiaceæ. The gymnospermic characters are principally Cycadean, though Cordaitean, and, in a minor degree, Araucarian characters appear less prominently in a few of the genera.

Types Generally Regarded as Cycadofilic

Cladoxylon.—One of the oldest though less known types with which we have to do is *Cladoxylon* of Unger, from the Lower Carboniferous of Thuringia.[1] The reference of this genus to the Cycadofilices rests on the characters of the stems which are polystelic. The steles, or vascular axes, as seen in transverse section are dilated radially, each stele including a broad central band of primary wood with one or several groups of spiral tracheæ, or primitive xylem elements, at the border. In the earlier stages the stem, even when of considerable size, is typically filicoid; but in most of the older stems each stele develops a zone of secondary wood with more or less numerous medullary rays. The tracheides of both primary and secondary wood are scalariform. The petioles show a structure distinctly characteristic of ferns, and, but for the secondary wood, the pteridophytic nature of the stems would be unquestioned.

The Medulloseæ.—Among the Paleozoic stems longest and best known by their internal structure are those of Cotta's genus *Medullosa.* These stems,[2] sometimes a foot or more in diameter, are polystelic (see plate LIV), the steles being irregular in form and dis-

[1] See Solms-Laubach, *Abh. d. k. Pr. geol. Landesanst.*, Heft, 23, 1896, p. 51.

[2] See Weber and Sterzel, *Beitrage zur Kenntniss der Medulloseæ;* Ber. naturw. Gesell. zu Chemnitz, vol. XIII, 1896, p. 44. See also Solms-Laubach, *Bot. Zeit.*, 1897, p. 175; Scott, *Phil. Trans.*, vol. 191, B, 1899, p. 81; Goeppert and Stenzel, *Palæontographica*, vol. XXVIII, 1881, p. 123.

tantly anastomosing. When numerous the smaller are mostly central, and the larger, more or less ribbon-like and dilated, are concentrically disposed near the periphery. Each stele contains a central axis of parenchymatous conjunctive tissue traversed throughout by anastomosing groups of primary strands. The larger groups, which are peripheral, include pitted tracheides, and are exarch.[1] Each stele is provided with a well-developed zone of secondary wood, loose and spongy in texture, with wide and high medullary rays (see plate LIV, fig. 2). The tracheides are multiserately punctate with bordered pits on their radial walls. The secondary wood is followed by cambium, phloem with phloem rays, and pericycle, while the entire group of steles is enveloped in a periderm surrounded by cortical short-celled parenchyma containing secretory canals suggestive of the gum canals of Cycads. In one species the outer steles are greatly broadened on the peripheral side so as practically to coalesce in a continuous zone or cylinder of normal secondary wood, the secondary wood of the inner side of the steles being inverted with reference to the whole trunk and often forming an inner cylinder of inward-growing exogenous wood. In another form (plate LIV, figs. 3 and 4) the entire stelic zone is surrounded by several successively developed extra-fascicular zones or layers of wood and phloem, an anomalous development which has an analogy in the living *Cycas* and *Encephalartos* also.

The leaf traces of *Medullosa* consist at first of both primary and secondary wood, each derived from its own kind on the peripheral side of the stele, in concentric arrangement; but in passing outward the secondary wood in most cases is lost, and the primary wood separates, while the pitted tracheids disappear, into many small collateral strands, the protoxylem being outward, next the phloem. Several leaf traces originating at different levels furnish large numbers of strands to a single petiole.

The petioles of *Medullosa,* before their final correlation with the parent stems, had been described as *Myeloxylon* and *Myelopteris.*[2] They comprise a ground mass of short-celled tissue including secre-

[1] In describing the arrangement of the woody elements in a bundle collateral in structure the terms "exarch," "mesarch" and "endarch" are used by Williamson and Scott according to the position of the primitive spiral tracheæ (protoxylem) at the outer border of the bundle, in the interior of the bundle, or at the inner border of the bundle.

[2] See Renault, *Mém. Sav. etr. Acad. Sci.,* vol. XXII, no. 10, 1876; Renault, *Cours de botanique fossile,* vol. III, 1883, p. 165; Zeiller, *Fl. Foss. bassin houill. et perm. d. Autun et d'Épinac,* pt. I, Paris, 1890, p. 282; Zeiller, *Éléments de Paléobotanique,* Paris, 1900, p. 131.

tory canals and somewhat concentrically arranged vascular bundles, the whole being surrounded by a thick hypodermal parenchymatous zone containing numerous longitudinal sclerenchymatous strands and secretory canals, and a layer of pallisade tissue. In their general structure they resemble Marattiaceous petioles.

Naturally the Medullosan stems were early regarded by most paleobotanists as more or less distinctly Cycadean; and this view is supported by the structure of the petioles, in which, in some species, a secondary wood accompanies the vascular strands. It must, however, be remembered that collateral primary bundles accompanied by secondary wood also occur in the Ophioglossaceæ.

The researches of Renault[1] have shown that the petioles (*Myeloxylon*) of *Medullosa* bear the large filicoid fronds, often tripinnate and quadripinnate, of the two great frond genera *Neuropteris* and *Alethopteris,* which previously had been generally considered as comprising the most common and characteristic Carboniferous ferns.[2] A portion of a frond of *Neuropteris,* from the Upper Carboniferous of Alabama, is shown in plate LV.

As long ago as 1889 Mr. Robert Kidston[3] described an imperfectly preserved specimen showing what appeared to be stalked synangia or quadrivalvate capsules in union with *Neuropteris heterophylla.* The pteridophytic nature of this fructification has been generally unquestioned, although, on the evidence of the relation of the fronds to *Medullosa,* the genus *Neuropteris* has been put with the Cycadofilices by many authors. The recent discovery by the same distinguished paleobotanist[4] of large solitary Rhabdocarpous seeds attached to the fronds of the same species of *Neuropteris* more than confirms the exclusion of these anomalous types from the ferns.

---

[1] *Comptes Rendus,* vol. 94, 1882, p. 1737.

[2] It is of interest to note, in this connection, that in the Lacoe fossil plant collection of the U. S. National Museum one of the rock slabs, about 110 cm. long and 55 cm. in width, contains a fragment from the interior of a frond of *Alethopteris aquilina* in which a rachis 3 cm. or more in width, lying near the border of the slab, gives off 6 alternate primary pinnæ, none of which is small enough to be included in its entirety within the area of the rock, while in the longest fragments of pinnæ, 65 cm. to the broken end, there is no diminution in width. It is impossible to say how high the whole segment may have been above the lowest primary pinnæ; but since none of the pinnules of the secondary pinnæ is even lobed it is evident that the specimen comes from the upper part of the frond. Doctor Scott (*Phil. Trans.* vol. 191B, 1899, pl. IX) figures a flattened petiolar base of *Medullosa* that is nearly 9 cm. in width.

[3] *Trans. Roy. Soc. Edinb.,* vol. XXXIII, pt. 1, p. 150.

[4] *Proc. Roy. Soc.,* vol. LXXII, Dec. 29, 1903, p. 487; *Trans.,* vol. 197B, 1904, p. 1.

The seeds described by Kidston differ but little in superficial characters, by which alone they are known, from *Rhabdocarpos tunicatus.* The genus *Rhabdocarpos,* which embraces a large number of Carboniferous species, includes generally large oval or oblong, ribbed and sometimes more or less distinctly trigoniate fruits characterized by an outer fleshy and an inner sclerotic test, and by chalaza, micropyle, nucellar membrane and pollenic chamber, while in certain silicified specimens, even pollen grains and archegonia have been observed. It represents one of the simple types of gymnospermous fruit. In these early Paleozoic types the fruit appears to have attained its full size before fertilization, and the pollen grains appear to have rested for some time in the chamber before the release of the antherozoids. No embryo has been observed.

Besides the fronds of *Neuropteris, Alethopteris,* and *Odontopteris,* which have been correlated with *Myelopteris,* and the genera *Callipteris* and *Linopteris* (*Dictyopteris* Gutb.) referred to the Medullosæ by European paleobotanists,[1] it is probable, in the judgment of the writer, that the related genera *Callipteridium,* and *Lesleya* together with *Megalopteris* and its closer relatives are also to be placed within the same enlarged group.

Colpoxylon.—The stem fragments described as *Colpoxylon* by Brongniart,[2] are interesting chiefly from the fact that they are monostelic in one part and polystelic in another, the solitary stele of the lower part of the stem being divided into several steles in passing upward. The structure of the latter, as well as of the petioles, is essentially like that of *Medullosa* to which the genus is evidently closely related.

The Lyginodendreæ.—Passing from the *Medulloseæ,* whose foliage is typified in *Neuropteris,* we will next consider the *Lyginodendreæ,*[3] whose fronds, so far as known, are included in the great frond genus *Sphenopteris.*

Heterangium of Williamson,[4] the most filicoid genus of the family,

[1] The genus *Nœggerathia,* originally placed among the Cycadofilices by Potonié on account of the arrangement of the "sporangia" on the ventral surface of the scales in the large strobili, is regarded by most paleobotanists as gymnospermous, though the nature of the reproduction is not definitely determined.

[2] See Renault, *Fl. foss. bassin houill. et perm. d. Autun et d'Épinac,* pt. 2, Paris, 1896, p. 299.

[3] An excellent and succinct description of this family is given by Dr. D. H. Scott, *Studies in Fossil Botany,* London, 1900, p. 307.

[4] Williamson, *Phil. Trans.,* vol. 178B, 1887, p. 289; Williamson and Scott, *Phil. Trans.,* vol. 186B, 1896, p. 703; Renault, *Fl. foss. bassin houill. et perm. d'Autun et d'Épinac,* pt. 2, 1896, p. 248.

resembles a fern in the habit of its delicate quadripinnate frond, the anatomy of its leaf, and its primary wood, while by the structure of the leaf trace bundles and secondary wood, with pitted tracheides, it appears to be related to the Cycadales.

The average *Heterangium* stem is less than 1.5 cm. in diameter, and includes: (1) a large central primary cylinder of anastomosing primary wood strands mingled with conjunctive parenchyma very much as in *Medullosa,* the outer wood strands, of mesarch collateral structure, with spiral, reticulate and pitted (multi-seriate, bordered) tracheides, forming a row, from which the leaf traces originate; (2) a thin zone of secondary wood, with tracheides bordered-pitted on the radial walls, and with broad medullary rays which give it a loose spongy texture; (3) a cambium; (4) phloem; (5) pericycle; (6) an inner cortex of short-celled parenchyma containing vertical rows of transverse sclerotic plates, comparable to the stone cells of living plants; (7) an outer cortex containing vertical strands forming radial and distantly anastomosing hypodermal plates. Adventitious roots spring from the primary wood strands. The petiolar strands, which, in one species, contain traces of secondary wood, are at first collateral, but become concentric on entering the petiole, which contains a single strand. The delicate frond is absolutely filicoid, tripinnate, and finely cuneately dissected, that of *Heterangium Grievii* being indistinguishable from, if not identical with, *Sphenopteris elegans.*[1]

The fructification of *Heterangium* is not definitely known, but it is possible that the male sporangia belong to the type described by Stur[2] as *Calymmatotheca.* The structures of primary stem, thick pericycle, and of petiole also are fern-like and have been compared by Doctor Scott with *Gleichenia;* but the mesarch outer primary strands, and the characters of the secondary wood, with pitted tracheides, strongly suggest the stems and petioles of Cycads.

Lyginopteris.—Very closely related to *Heterangium* is the genus *Lyginopteris* of Potonié[3] (*Lyginodendron* Williamson), for whose beautiful and complete elaboration we are indebted to Williamson[4] and Scott.[5] In the form of its fronds, its microsporangia, and in

[1] *Phil. Trans.,* vol. 163, 1873, p. 377; vol. 164, pt. 2, 1874, p. 675; vol. 166, 1876, p. 1; vol. 178B, 1887, p. 289; vol. 181B, 1890, p. 89.

[2] *Phil. Trans.,* vol. 186B, 1896, p. 703.

[3] *Lehrb. d. Pflanzenpalæont.,* p. 171.

[4] See Stur, *Abh. d. k.-k. geol. Reichsanst.,* vol. VIII, pt. 2, Wien, 1877, p. 130.

[5] Loc. cit., p. 149. See also Kidston, *Trans. Roy. Soc. Edinb.,* vol. XXXII, pt. 1, 1889, p. 137.

the young roots *Lyginopteris* is typically a fern. In its stems, petioles, and seeds it is largely Cycadaceous, though the stems present some analogies with *Osmunda* also.

The stems of *Lyginopteris* (see plate LIII), which are several centimeters in diameter,[1] are monostelic, the center being occupied by a large pith, at the periphery of which occur several (5–8) large, more or less isolated, collateral bundles of small spiral, scalariform, and bordered-pitted tracheides in mesarch structure. Next we have a thick zone of secondary wood consisting of radially and pluriseriately pitted tracheides and broad medullary rays, both direct and secondary. The cambial zone is followed by phloem, which also is rayed. External to this is the pericycle, several cells thick, a thin periderm, a tender, inner, and a resistant outer cortex, which is characterized by radial sclerenchymatous plates longitudinally flexuose-anastomosing so as to form a rhomboidal net in tangential section, the meshes being occupied by parenchyma ("*Dictyoxylon* structure").

The leaf traces, arising from the chief primary strands, break through the secondary wood, and are collateral and twinned while ascending in the pericycle, but they become concentric and V- or W-shaped, without secondary xylem, in the petiole.

The adventitious roots, which were published as *Kaloxylon* by Williamson prior to correlation with the stems, are described by Doctor Scott as exhibiting in their early stages, less than 5 mm. in diameter, 2–8 strands of primary wood in an arrangement closely resembling that of the roots of the Marattiaceæ, or of the Ophioglossaceæ, though when larger they show secondary tissue in a structure "absolutely indistinguishable from that of typical dicotyledons or gymnosperms."

The petioles (originally described as *Rachiopteris aspera* Will.) of *Lyginopteris oldhamia* are found in organic union with the very large, highly compound, finely dissected fronds of *Sphenopteris Hoeninghausii* Brongn.,[2] one of the common species in the Lower Coal Measures of Europe and America. These fronds are so typically filicoid that only anatomical identity in every detail or actual union could suffice to remove them from their previously unquestioned place among the ferns. The reference of the *Calymmatotheca* form of long, sack-like, clustered bodies, regarded as exannulate sporangia, to the *Hoeninghausii* group of Sphenopterids has

[1] *L. robustum* Seward is represented as about 12 cm. in diameter.

[2] Plate LIII, Figure 2. See also Zeiller, *Flore fossile du bassin houill. de Valenciennes*, 1888, p. 82, pl. V, f. 3, pl. VI, f. 1, 2.

recently been supported by Miss Benson,[1] who discussed the connection of these organs with *Lyginopteris* not long before the indisputable correlation, by Oliver and Scott,[2] of seeds (*Lagenostoma* of Williamson) with the same plant, on the basis of the strongly characteristic anatomical features. The fruit described as *L. Lomaxi* is orthotropous, small, only about one-half a centimeter in length, and is borne in pedicellate cupules. The seed, with chalaza, testa, nucellar epidermis, pollenic chamber, etc., is essentially gymnospermic in structure, though exhibiting certain very unique and striking features.

While related to the ferns by its leaves, young roots, and microsporangia, the predominant analogies of *Lyginopteris* are gymnospermous. The mesarch arrangement of the elements in the primary wood strands is to be compared with the structure in the petioles and peduncles of certain living Cycads to which it is almost peculiar. The change in the leaf strand from the collateral to the concentric form while passing to the petiole also finds an analogy in *Osmunda*. The very large pith and the loose spongy secondary wood suggest the Cycads, and the seeds are comparable to those of *Ginkgo*.

Megaloxylon.—The genus *Megaloxylon* of Seward[3] includes stems of considerable size which contain a large primary cylinder of short tracheides mingled with parenchymatous tracts. The thick secondary wood is like that of *Lyginopteris*. The genus is thus closely related by its primary stele and its centrifugal xylem to both *Heterangium* and *Lyginopteris;* but it differs by the exarch structure of the bundle in both the primary xylem and the leaf trace.

Calamopitys.—Closely related to *Lyginopteris* are the slender monostelic stems, from the Lower Carboniferous of Thuringia, described by Unger as *Calamopitys*. This stem[4] has pith, primary and secondary wood like that of *Lyginopteris*. The centripetal tracheides are pitted on all sides; the centrifugal on the radial walls only. *Calamopitys* differs from the genus last mentioned by the change in the leaf strands to a concentric structure on entering the cortex, and by the separation of the strand into several bundles arranged in a ring in the petiole. The structure of the petiole, which accordingly is fern-like, appears to be identical with that of *Kalymma grandis* Ung., which has also been reported from the Middle Devonian Black

[1] *Ann. Bot.*, vol. XVI, 1902, p. 575.

[2] *Proc. Roy. Soc.*, vol. LXXI, no. 474, May 26, 1903, p. 477; *Philos. Trans.*, vol. 197, B, 1904, p. 193.

[3] *Proc. Cambr. Phil. Soc.*, vol. X, 1899, p. 158.

[4] See Solms-Laubach, *Abh. k. Preuss. geol. Landesanst.*, Heft. 23, 1896, pp. 63 and 43; also Dawson and Penhallow, *Can. Rec. Sci.*, vol. IV, 1891, p. 1.

Shale of Kentucky. The fronds and fructification of *Calamopitys* are unknown.

The Cycadoxyleæ.—The stems published by Renault[1] as *Cycadoxylon* are still closer to the Cycads, and their secondary wood is described as distinctly Cycadean. But the *Cycadoxylon* stem presents a strikingly anomalous feature in the occurrence, within the cylinder of outer (normal) secondary wood, of two or more distinct zones of inner crescentic secondary wood, each zone of which with its rays and accompanying broad phloem bands, lies in an inverted position in the body of the pith. The genetic connection with *Lyginopteris* is shown not only in the general characters of the centrifugal wood but also by a slight development of a similar medullary secondary wood in certain specimens of the latter genus.

An important link between the Lyginopterid group and the Cycadales (in a broad sense) is furnished by the stems described by Renault[2] as *Ptychoxylon,* another of the Cycadoxyleæ, which is regarded by both its author and Doctor Scott as essentially Cycadaceous. In this genus (see plate LIV, fig. 1) a very large pith is surrounded by a more or less complete narrow zone of secondary wood similar to that of the other stem genera. But within the cylinder of normal centrifugal wood lie several concentric arcs of fully developed inverted secondary wood, each with its phloem, medullary rays, and phloem rays. At the leaf gaps the edges of the interrupted outer or normal cylinder curve inward to coalesce temporarily with two of the inner arcs of inverted exogenous wood, which are termed "reparatory" arcs. In the relations of the normal and inverted secondary woods *Ptychoxylon* appears to present some analogies with *Colpoxylon* and *Medullosa.* No primary wood appears yet to have been observed in the petrified stems, though the leaf trace is said to be essentially like that of *Lyginopteris.*

Except for the anomalous medullary wood *Ptychoxylon* is Cycadaceous; and this systematic reference is supported by the discovery, in the same beds,[3] of leaves (*Pterophyllum* and *Sphenozamites*) which in form and external characters are distinctly Cycadean, accompanied by a remarkable inflorescence (*Cycadospadix milleryensis* Ren.) provisionally referred to *Ptychoxylon* by Renault.

Protopitys.—In Goeppert's *Protopitys* originally described from the Lower Carboniferous of Silesia and more fully made known by

[1] *Flore fossile du bassin houill. et permien d'Épinac,* pt. 2, 1896, p. 307; Williamson, *Phil. Trans.,* vol. 163, 1873, p. 377; Williamson and Scott, *Phil. Trans.,* vol. 186B, 1896, p. 703; Seward, *Ann. bot.,* vol. XI, 1897, p. 65.

[2] Op. cit., p. 329.

[3] Loc. cit., p. 329.

Count Solms-Laubach[1] we have another unique type of stem combining filical and gymnospermic characters and referred by Doctor Scott to the Cycadofilices, though gymnospermous characters predominate. Its secondary wood, of coniferous structure, contains a large elliptical pith bordered by a continuous zone of primary wood which is thicker and somewhat complex at the ends of the ellipse, whence the leaf strands originate. This genus, on which Count Solms founds a family, appears to the writer to resemble so closely certain of the woods described as *Dadoxylon* (*Cordaites*) as to demand a reëxamination of some of the material showing secondary wood only and referred by authors to the latter genus.

Fossil plants petrified in such a way as to show their microscopical structure are extremely rare in the Carboniferous series of this country, and but few fragments excepting those of *Dadoxylon* and *Psaronius* have come to light. Impressions or carbonized remains are, however, as common in the Coal Measures of America, particularly in the Appalachian trough, as in other parts of the world. Our knowledge of the Cycadofilices, so far as it proceeds from American material, is based almost entirely on these carbonized remains.

Aneimites (*Adiantites* of authors).—The genus *Aneimites* is represented by several species in the basal Coal Measures of both Europe and America, though no petrified specimens (having structure) of that genus are known, and until recently we have had no clue to its fructification. Conclusive data relating to the latter have been furnished by material from the lower Pottsville along New river in southern West Virginia. The fronds, which are commonly known as *Adiantites*, are tripinnate, with slender divisions of the rachis and very deeply dissected cuneate pinnules and lobes, which, as the early name for the genus implies, strongly resemble those of *Adiantum*.[2] The seeds, borne on dichotomous pedicels at the periphery of the somewhat reduced fertile fronds, are small, about .5 cm. long, rhomboidal, and vascularly striate, thinly lenticular in transverse section, the outer envelope being laterally dilated, especially below the middle of the seed, so as to form a wing to the fruit. The seed, seen in all stages of development, is deciduous at maturity by abscission at the broadened apex of the pedicel. The general characters, so far as recorded by the impressions, appear in the main to be conformable to the primitive types of gymnosperms.

---

[1] *Bot. Zeitung*, 1893, p. 197.

[2] See *Smithsonian Miscell. Colls., Quarterly Issue*, vol. 47, pt. 3, p. 322, pl. XLVIII.

Microsporiferous organs of two forms are intimately associated with the fronds, one of them belonging to the *Calymmatotheca* type. The latter, however, is not found in union with the frond. The discovery of seeds in connection with the *Aneimites* group of supposed ferns necessitates the systematic transfer of this group to the Pteridospermeæ. This reference is based solely on the evidence of the fructification, the anatomical characters of the fronds, whose fern nature had not before been questioned, being still unknown, though the form of the rachis suggests a single petiolar strand like that of *Heterangium*. *Aneimites* is the third Cycadofilic genus in which the seeds are definitely correlated through union with the sterile portions of the frond.

Types Probably Cycadofilic

It has been seen that the reference to the Cycadofilices of the genera individually discussed above is based on (*a*) the anatomical characters of the stems and petioles; and (*b*) on the discovery of seeds still attached to or definitely identified with the fronds, this category being represented by but three types, *Medullosa* (*Neuropteris*), *Lyginopteris*, and *Anemites* (*Adiantites*). Besides these there is a third category, more indefinite and unsatisfactory, but worthy of mention as *provisionally* referable to the same phylum. It is based (*c*) on their evidently close relationship to one of the above mentioned Cycadofilic genera; on the circumstantial evidence of association; or on the negative evidence of the absence of any recognized filicoid type of fructification.

The third Pteridospermic category includes common genera, not petrified so as to show their internal anatomy, found as impressions or carbonized remains at many hundreds of localities in Europe or America, but whose fructification is not yet known. Some of these genera, which are still placed among the ferns, appear to be habitually associated with certain generic types of seeds in a way to strongly suggest a former union as well as a common source. Thus Grand 'Eury, who more than any other paleobotanist has contributed to our knowledge of the habits of the Paleozoic plants in situ, in two recent papers[1] concludes not only from the absence of rhizomes and connected fructifications, but from the large number of genera of Coal Measures seeds that are unaccounted for and the habitual association of some of the latter with fronds of the Neuropterideæ, that *Pachytesta* is referable to *Alethopteris;* that certain small striate

[1] *Comptes Rendus,* vol. 138, March 7, 1904, p. 607; vol. 139, July 4, 1904, p. 23.

winged seeds (*Odontopterocarpus*) belong to *Odontopteris;* that certain Trigonocarpous seeds, occasionally showing Rhabdocarpous characters also, belong the *Neuropteris* and *Linopteris;*[1] and that some rarely observed minute floral vestiges and smooth capsules, resembling the Arkansas specimens referred by Lesquereux[2] to *Sorocladus,* represent the polleniferous organs of *Neuropteris.* Concerning the typical Neuropterids this distinguished savant believes that they "grew from seeds and are primitive Cycads with fern fronds." [3]

Mention has already been made, in the discussion of the Medulloseæ, of the probable Cycadofilic nature of *Callipteridium, Lesleya,* and the Megalopterids, on the basis of what the writer regards as their distinct affinities with the Neuropterid group, and on account of the absence of all traces of fructification in these genera. On the basis of similar strong though negative evidence it becomes not improbable that the supposed fern genera *Mariopteris, Pseudopecopteris* (including the round-lobed Diplothmemæ), *Eremopteris* and *Triphyllopteris* (with *Sphenopteridium*), no trace of whose fructification has yet been found, and whose internal organization is unknown, will eventually be found to belong to the Pteridospermeæ. It is possible, however, that in the cases of some of these genera the identity of the reproductive organs is masked by dimorphism, which seems to have been as prevalent among the ferns of the Paleozoic as it is among those of to-day.

On the other hand, it is far from impossible that some of the types which, solely on the evidence of the anatomical characters of their stems, have been referred to the Cycadofilices may eventually be correlated with some of the isosporous fronds already in hand among the ferns. The lessons learned from *Calamites, Lepidodendron,* and *Sphenophyllum,* which, notwithstanding the development of prominent as well as varied secondary woods, are none the less Equisetales, Lycopodiales, and heterosporous Sphenophyllales respectively, teach us that the accession of secondary wood, even of a structure regarded by many botanists as gymnospermic, should not be accepted as *de facto* proof of an ordinal difference in rank. This important fact should be constantly kept in view, and more particularly when discussing the systematic relations of some of the genera founded

[1] The sporangia approximating the *Crossotheca* type, described by Zeiller (*Fl. foss. bassin houill. d. Commentry,* pt. 1, 1888, p. 273) in one of the afore-mentioned genera, *Linopteris,* probably represents, as suggested by Grand 'Eury, only the male sporangia of the genus.

[2] *Coal Flora,* vol. 1, p. 328, pl. XLVIII, f. 8.

[3] *Comptes Rendus,* July 4, p. 23.

only on petrified stems, such for example as *Cladoxylon* and *Calamopitys,* which differ essentially from ferns only by the presence of their secondary wood. It must also be remembered that both secondary wood, of a sort, and collateral bundles are found in the Ophioglossaceæ.

Conclusions

The development of secondary xylem in various Cryptogamic families among Carboniferous plants, in various species of the same genus, and at various stages and positions, in the growth of the plant conclusively supports the view, long ago suggested by Williamson in the case of *Calamites,* that secondary wood originated as an engineering feature—a mechanical aid for the support of the gigantic Carboniferous representatives of some of our humble modern families. As such its origin was doubtless polyphyletic and, naturally, since the types appeared in different geological stages, polychronous.

The varied phases in which this secondary wood appeared—in polystelic, inverted intra-medullary, extra-fascicular or accessory, and laterally alternating, as well as modern phases, with their remarkable differences in combination, and in varying degrees of complication—constitute a group of structural anomalies which in themselves offer the evolutionist strong testimony of fortuitous variation. It is as though Nature were at the Carboniferous moment in the midst of a series of amazing engineering experiments, most of which were either buried deep in Paleozoic oblivion, or permitted to survive only as vestigial relics and atavistic ghosts.

Our knowledge of the structures and fructifications of the Cycadofilices (Pteridospermeæ) leaves little room for doubt as to the descent of the Cycads, and perhaps some of the other modern gymnospermous types,[1] from the ferns, though, as Doctor Scott has taken pains to point out, it does not follow that any of the Coal Measure types yet discovered actually represent the *lineal* ancestors of our living gymnospermic genera.

The discovery of seed-bearing members of the Cycadofilices, while answering in part the old question as to the origin of the gymnosperms, injects, at the same time, a new biological problem into the field of inquiry,—viz., the origin of the Cycadofilices. Seeds of so high and so gymnospermoid an organization as *Lagenostoma* or

[1] There is important data in support of the view that a portion, at least, of the conifers were derived from the Paleozoic Lycopodiales through a group of Lycopodineous seed plants whose existence is predicated partly on paleontological indications, partly on theoretical grounds, rather than definitely known or established, and for which Professor Ward (*Science,* Aug. 26, 1904, p. 281) has proposed the class term "Lepidospermæ."

Rhabdocarpos were, on the whole, hardly to be expected in view of the typically filicoid habits of the fronds, the presence of distinctly pteridophytic characters in the stems and petioles, and the antiquity of the seed-bearing types.

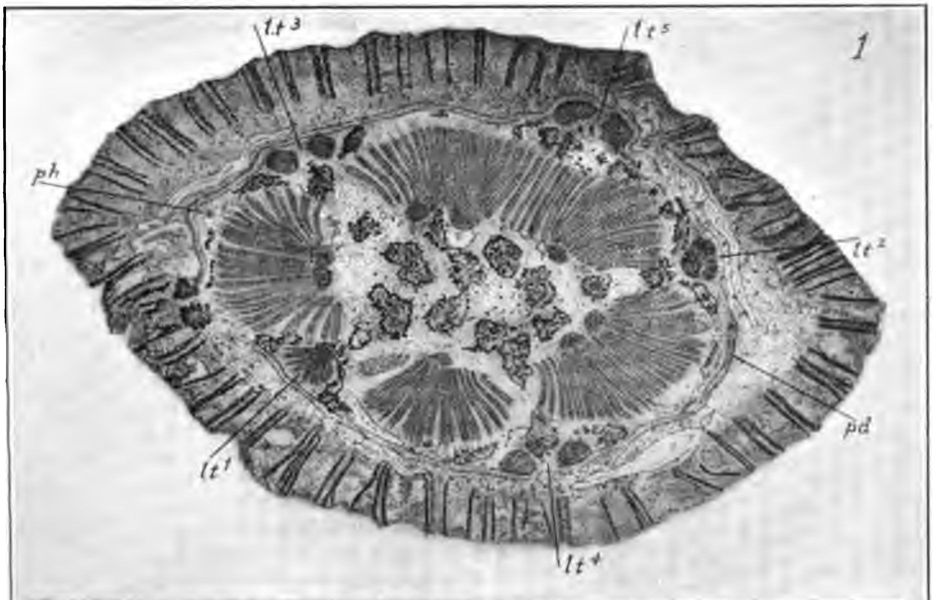
Since *Lyginopteris, Calamopitys,* and *Protopitys* are present in rocks of Lower Carboniferous age, it follows that the heterosporous filices, which must have antedated the Cycadofilices, are to be looked for at the very base of the Carboniferous, if not, as is more probable, in the Upper Devonian. *Triphyllopteris,* which the writer believes to be Pteridospermic, occurs near the base of the Lower Carboniferous in America. Concerning the Pteridospermic nature of the specimens reported as *Kalymma grandis* from the Black Shale of Kentucky, there appears to be room for doubt. Should, however, the interpretation of these fossils prove valid, the Cycadofilices will go back to the Middle Devonian (Genessee), or nearly as far as the oldest plant fossils generally recognized as unquestionably ferns. The presence of gymnosperms at this early date is generally accepted on the evidence of the occurrence of fossil woods representing several species of *Dadoxylon,* which includes the trunks of Cordaites. Some of these early species have, as has already been suggested, very much in common with *Protopitys.*

In a discussion of the recent discoveries relating to the Cycadofilices, which he seems inclined to regard as gymnosperms, Professor Zeiller remarks that it may become necessary to refer to the Carboniferous as the epoch of the gymnosperms, rather than of the Cryptogams. Whatever the limits and final interpretations of the Cycadofilices, they constitute a well-marked filicoid group preëminently characteristic of the Carboniferous, which may appropriately be paleobotanically designated as the epoch of the Pteridosperms—the seed-bearing ferns.

Explanation of Plate LIII

Fig. 1. Cross-section of a stem of *Lyginopteris oldhamia*, about 4½ times the natural size. At the margin of the large central pith area. which contains numerous sclerotic nests, are the primary wood strands (*x*), eight in number; external to these is the broad zone of secondary wood (with cambium and secondary phloem), interrupted by the passage of the leaf traces; *ph*, a primary phloem group; *pd*, periderm, limiting the pericycle which contains other sclerotic groups; *lt* 1–*lt* 5, leaf traces (numbered in the order of their phyllotaxy) becoming twined while ascending in the pericycle; the periderm is followed by the inner cortex and the outer cortex, the latter with its radial plates, the longitudinal anastomoses of which are not seen in the cross-section. From the Lower Coal Measures at Oldham. After Williamson and Scott.

Fig. 2. Fragment, in natural size, from a portion of the frond of *Sphenopteris Hœninghausii*, the leaf of *Lyginopteris*. From the Pottsville near Quinnimont, West Virginia.



STEMS OF CYCADOFILICES

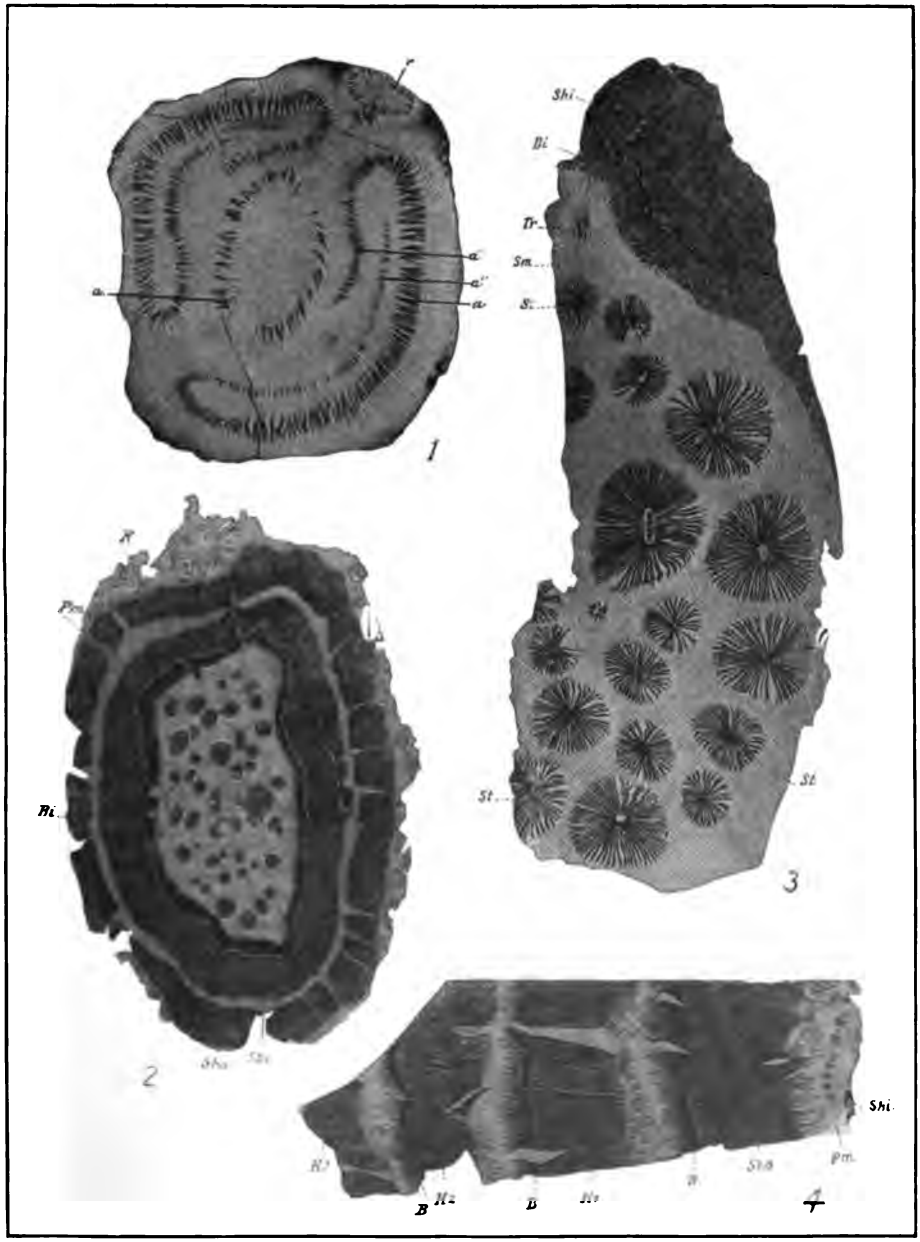
Explanation of Plate LIV

Fig. 1. Cross-section of stem, ***Ptychoxylon Levyi***, enlarged a little more than one-half. *a*, outer zone of secondary wood, bordered with an equally wide zone of rayed phloem, the whole being normal or centrifugal in growth; *a′* and *a″*, zones of inverted secondary wood in bands temporarily continuous with the outer zone at the openings where branches have broken through, one of the latter, *r*, being still included in the section; a_1 inner zone or cylinder of inverted or centripetal wood with medullary rays, and rayed phloem; *r* branch with secondary wood. In this specimen the pith cells and primary wood are not shown, while the cortical tissues were lost before petrification. From the Permian of Autun. After Renault.

Fig. 2. Cross-section of stem of ***Medullosa stellata*** var. ***typica***, slightly reduced. Small steles, each with its centrifugally developed secondary wood, are scattered in the central (principal) medullary area; *sha*, outer, normal, secondary wood; *shi*, zone of inner and inverted secondary wood, the medullary elements not appearing in the illustration; *Bi*, zone of inner phloem or bast of the inverted exogenous wood; the white line indicates the cambial zone; *R*, portion of cortex. From the Permian of Chemnitz. After Weber and Sterzel.

Fig. 3. Portion of the section of the interior of a trunk 48 cm. in diameter, of ***Medullosa stellata*** var. ***gigantea***, about 9/10 the natural size. *Sm*, ground mass of central pith containing a number of small steles, *st*, with their radiate secondary wood, the primary elements being shown in the centers of some of the larger medullary steles; *Shi*, portion of inner zone of the enveloping cylinder of inverted or centripetal secondary wood with its thick phloem, *Bi*. *Bi*.

Fig. 4. Cross-section of a fragment of the same specimen and just external in position to that seen in figure 3. *Shi*, small fragment of the inner, inverted, zone of secondary wood seen in the previous figure; *Pm*, partial pith, including bundles, probably of primary wood; *Sha*, normal or centrifugal secondary wood, with phloem, *B*, and phloem rays; H_1B, and H_2B, succeeding zones of secondary wood with rayed phloem zones. From the Permian of Chemnitz. After Weber and Sterzel.



STEMS OF CYCADOFILICES

EXPLANATION OF PLATE LV

Fragment of a frond of *Neuropteris* cf. *Smithii*, about 2/5 the natural size. The fronds early described as *Neuropteris* are now recognized as merely the foliage of *Medullosa*. From the Pottsville at Warrior, Alabama. Collection of Alabama State Geological Survey.

NEUROPTERIS, A CYCADOFILIC FROND

NOTES

REPORT BY W. H. HOLMES ON THE CONGRESS OF AMERICANISTS HELD AT STUTTGART, GERMANY, AUGUST 18–23, 1904

On July 26 I sailed from New York in company with Mr. J. R. Marshall of the firm of Hornblower and Marshall, architects of the new U. S. National Museum building, and reached Plymouth, England, August 1. Nine days were spent in visiting the museums of London, Oxford and Cambridge, and eight days in similar work in Paris, and on August 18 I reached Stuttgart. The opening session of the Congress of Americanists was held in the forenoon of that day and was attended by a large number of members and other prominent persons including His Majesty, King William II of Würtemberg, who in response to the address of the President of the Congress, Professor Karl von den Steinen, expressed at length his appreciation of the aims and work of the Congress, and his pleasure at having the present session held in his capital city—Stuttgart. A report of the meeting of the Congress held in New York City in 1902 was read by Dr. Franz Boas, of the Natural History Museum, New York, and other routine business was transacted. The Congress was invited to take luncheon with the King in his suburban palace and many members of the Congress and their friends attended. Afterwards a reception was held in the palace gardens. The King's interest was highly appreciated and contributed much to the success of the Congress. During the presence of the Congress receptions were also held at the residences of Count von Linden, vice-president of the Congress, and Mr. Edward N. Ozmun, U. S. Consul at Stuttgart. Sessions were held on the nineteenth, twentieth, twenty-second, twenty-third, and twenty-fourth, and a large number of papers were read dealing in the main with questions of American history, ethnology and archeology, the programme being as follows:

PROGRAMME

(This list includes some papers of which only abstracts were submitted)

FRIDAY, AUGUST 19

PROF. DR. E. FRAAS: Comparison of the Jurassic Formation of America and Europe.

DR. HANS MEYER: Historic Man in the Andean Regions of Equatorial South America.

DR. HENRI FROIDEVAUX: A New Chapter in the History of the Filibusters of the Antilles (The Filibusters of Darien during the 18th Century).

DR. ANGVAR NIELSEN: The Relations of Norway and Greenland and North America during the Middle Age and their Repetition in the 18th Century.

DR. W. RUGE: A Globe of Gemma Frisius.

DR. AUGUST WOLKENHAUER: Was the Magnetic Declination Before Columbus' First Voyage (1492) as a Matter of Fact Unknown?

PROF. DR. LEJEAL: The Memoirs of Fray Toribio, Motolinia.

PROF. JOS. FISHER, S.J.: The Cartography of the Discoveries of the Norsemen in America.

SATURDAY, AUGUST 20

DR. OWAN BLOCH: The Origin of Syphilis (Morbus americanus).

PROF. W. H. HOLMES: Contributions of American Archeology to the Science of Man.

DR. CLEMENTS E. MARKHAM: The Megalithic Age in Peru.

DR. JONKEER VAN PANHUYS: The Last Dutch Expedition to Surinam.

COMTE G. DE CREQUI: The Excavations of the French Mission to Tiahuanaco.

COMTE G. DE CREQUI: The Excavations of the Prehistoric Necropolis of Calama. The Atacamas.

MONDAY, AUGUST 22

PROF. DR. K. SAPPER: Manners and Customs of the Pokonchi Indians.

DR. FRANZ BOAS: Influence of the Social Foundation of the Kwakiutl Indians upon their Culture.

DR. K. T. PREUSS: Sun Feast of the Old Mexican and the Moki.

PROF. DR. FRITZ REGEL: Remarks Concerning the Residue of the Wild Tribes of the West Antioquia.

DR. VAN PANHUYS: Observations on the Ornaments of the Primitive People of Dutch Guiana.

HERR MEYER: The Art of the Chinguin Indians.

DR. A. PLAGEMANN: Report upon the Chilian Pintados.

DR. EDUARD SELER: The Greenstone Idol of the Stuttgart Museum.

DR. EDUARD SELER: The Ancient Inhabitants of the Castle of Teayo.

DR. WALTER LEHMANN: A Chapter from Mexican Mythology.

TUESDAY, AUGUST 23

DR. WALDEMAR JOCHELSON: Concerning the Asiatic and American Elements in the Myths of the Koriaks.

PROF. WALDEMAR BOGORAS: Religious Ideas of Primitive Man from Chukchee Material.

DR. P. EHRENREICH: Distribution and Migration of the Myths of the South American Peoples and their Connection with those of North America and the Old World.

PROF. ROBERT LEHMANN: European Stories Among the Araucaneans of Argentina.

DR. L. C. VAN PANHUYS: A European Custom of Pagan Times brought over to America.

MR. WILLIAM THALBITZER: Eskimo Dialects and Migrations.
REV. CHARLES W. CURRIER: The Indian Languages of the United States.
M. PABLO PATRON: General Writings of America.
M. DE LA GRASSERIE: On the Tehuelche Language.

Besides myself, representing the Smithsonian Institution, the National Geographic Society and the American Association for the Advancement of Science, there were present from America, the Duke of Loubat, patron of American archeological research, Dr. Franz Boas, representing the Natural History Museum, New York, and the Reverend C. W. Currier, representing the Catholic University of America, Washington. Several other countries were represented.

On the twentieth I had the honor to preside at the meeting of the Congress and in the afternoon delivered an address on "Contributions of American Archeology to the Science of Man." A copy of the address accompanies this report. At the close of the address I had the pleasure of presenting to the Congress a set of 75 bound volumes relating mainly to American archeology and ethnology published by the Smithsonian Institution and its two bureaus—the National Museum and the Bureau of American Ethnology—for which the President extended the thanks of the Congress. The list of publications presented is as follows:

LIST OF PUBLICATIONS

ABBOTT: Stone Age in New Jersey.
BOEHMER: Prehistoric Naval Architecture of the North of Europe.
BRANSFORD: Archeological Researches in Nicaragua.
CARR: Mounds of the Mississippi Valley.
DALL: Remains of Later Prehistoric Man from Alaska and the Caves of the Aleutian Islands.
FEWKES: Archeological Field Work in Arizona.
FEWKES: Archeological Trip to the West Indies.
FEWKES: Expedition to the Pueblo Ruins near Winslow, Arizona.
FEWKES: Cliff Villages of the Red Rock.
FEWKES: Archeological Expedition to Arizona in 1895.
FEWKES: Two Summers' Work in Pueblo Ruins.
FOWKE: Archeologic Investigation in James and Potomac Valleys.
FOWKE: Stone Art.
GANN: Mounds in Northern Honduras.
GILLMAN: Certain Characteristics Pertaining to Ancient Man in Michigan.
GILLMAN: Mound Builders in Michigan.
HABEL: Sculptures of Santa Lucia Cosumalwhuapa, Guatemala.
HAVEN: Archeology of the United States.
HENSHAW: Animal Carvings from Mounds of the Mississippi Valley.
HENSHAW: Perforated Stones from California.
HOLDEN: Central American Picture Writing.

Holmes: Ancient Art of the Province of Chiriqui.
Holmes: The use of Gold and other Metals among the Ancient Inhabitants oi Chiriqui.
Holmes: An Ancient Quarry in Indian Territory.
Holmes: Ancient Pottery of the Mississippi Valley.
Holmes: Anthropological Studies in California.
Holmes: Art in Shell of the Ancient Americans.
Holmes: Development of the Primal Shaping Arts.
Holmes: Flint Implements and Fossil Remains from a Sulphur Spring at Afton, Indian Territory.
Holmes: Origin and Development of Form and Ornament in Ceramic Art.
Holmes: Illustrated Catalogue of Collections of the Bureau of Ethnology for 1881.
Holmes: Pottery of the Ancient Pueblos.
Holmes: Prehistoric Textile Art of Eastern United States.
Holmes: A Study of the Textile Art.
Holmes: Textile Fabrics of Ancient Peru.
Holmes: Aboriginal Pottery of the Eastern United States.
Holmes: Development of the Primal Shaping Arts.
Holmes: Evidence Relating to Auriferous Gravel Man in California.
Holmes: Fossil Human Remains near Lansing, Kansas.
Hough: Archeological Field Work in Northeastern Arizona, Museum-Gates Expedition of 1901.
Hough: The Lamp of the Eskimo.
Jones: Aboriginal Remains of Tennessee.
Jouy: Korean Mortuary Pottery.
Lapham: Antiquities of Wisconsin.
Mason: Guesde Collection of Antiquities in Pointe-a-Pitre.
Mason: Lattimer Collection of Antiquities in Pointe-a-Pitre.
Mayer: Observations on Mexican History and Archeology.
McGuire: Pipes and Smoking Customs of the American Aborigines.
McGuire: Study of the Primitive Methods of Drilling.
Mindeleff: Aboriginal Remains in Verde Valley.
Mindeleff: Casa Grande Ruin, 1890.
Mindeleff: Repair of Casa Grande Ruin, 1891.
Mindeleff: Cliff Ruins of Canyon de Chelly.
Mindeleff: Pueblo Architecture.
Muniz and McGee: Primitive Trephining in Peru.
Packard: Pre-Columbian Copper Mining in America.
Pickering: On the Gliddon Mummy Case in the National Museum.
Rau: Lapidarian Sculptures.
Rau: Articles on Anthropological Subjects, 1863–77.
Rau: Prehistoric Fishing in Europe and North America.
Rau: Archeological Collection of the United States National Museum.
Rau: Palenque Tablet in the United States National Museum.
Thomas: Burial Mounds of the Northern Sections of the United States.
Thomas: Catalogue of Prehistoric Works.
Thomas: Circular Square and Octagonal Earthworks
Thomas: Day Symbols of the Maya Year.
Thomas: Manuscript Troano.
Thomas: Maya and Mexican Manuscripts.

THOMAS: The Maya Year.
THOMAS: Mayan Calendar Systems.
THOMAS: Mayan Calendar Systems.
THOMAS: Mound Explorations.
WHITTLESEY: Ancient Mining on the Shores of Lake Superior.
WHITTLESEY: Descriptions of Ancient Works in Ohio.

I also presented to the Congress a set of 66 photographs of American Indians, the series taken conjointly by the Bureau of American Ethnology and the National Museum, of the delegations of aborigines which visited Washington during the winter of 1903–4. The following tribes are represented:

TRIBES

Cayuga	Omaha	Sioux Santee
Iowa	Oneida	Sioux Sisseton
Kickapoo	Onondaga	Sioux Yankton
Klamath	Osage	Tuscarora
Muskogee Creek	Sac and Fox	Wenatchi
Navaho	Seneca	Yakima
Nez Perce	Sioux Oglala	

Various excursions were made to points of interest, the principal one being to Schaffhausen, Switzerland, to visit the sites of Dr. J. Nuesch's recent explorations of the famous lake dwelling stations at Schweizerbild and Koenigsbau. On the twenty-second I found it necessary to leave Stuttgart in order to meet Dr. A. B. Meyer, Director of the Dresden Museum, consultation with him being a leading feature of my museum programme.

After leaving Dresden a number of cities in Germany, Holland, and Belgium were visited with a view to museum study, and on August 12 I returned to Paris and on the twenty-fifth sailed from Cherbourg, en route to New York. Between the date of my arrival in Plymouth, August 1, and my departure from Paris, September 25, I visited and made studies of upwards of 50 museums, the observations made being embodied in a separate report to be submitted at a later date.

INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

Since the publication of the note on the International Catalogue of Scientific Literature in Smithsonian Misc. Coll. (Quarterly Issue), Vol. 1, pp. 213–215, the following volumes have been received and distributed to the subscribers in the United States: First Annual Issue, Zoology (completing the issue); Second Annual Issue, Mathematics, Mechanics, Physics, Meteorology, Mineralogy, Geology, Geography, Palæontology, General Biology, Human Anatomy, Physical Anthropology, Physiology, Bacteriology, and Supplementary List of Journals; Third Annual Issue, Astronomy.

RECENT PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST OF NOVEMBER, 1904, IN PUBLICATION NO. 1478

No.	Title	Series	Price
1489	Proceedings of Regents, Report of Executive Com-	R. 1903	.05
	mittee, Acts of Congress, etc.	R. 1903	.05
1490	SHALER, N. S. General description of the moon..		
1491	NICHOLS, E. F. *and* HULL, G. F. The pressure	R. 1903	.05
	due to radiation		
1492	NORDMANN, CH. The sun-spot period and the		
	variations of the mean annual temperature of	R. 1903	.05
	the earth	R. 1903	.05
1493	PERNTER, J. M. Methods of forecasting the weather		
1494	BADEN-POWELL, B. Progress with air ships	R. 1903	.05
1495	CHANUTE, O. Aerial navigation	R. 1903	.05
1496	[BELL, A. G.] Graham Bell's tetrahedral kites	R. 1903	.05
1497	CURIE, E. Radium	R. 1903	.05
1498	THOMSON, J. J. Radium	R. 1903	.05
1499	RAMSAY, WM. *and* SODDY, F. Experiments in radio-activity and the production of helium from radium	R. 1903	.05
1500	ABBOT, C. G. The "N" rays of M. Blondlot	R. 1903	.05
1501	LODGE, OLIVER. Modern views on matter	R. 1903	.05
1502	CROOKES, WILLIAM. Modern views on matter: the realization of a dream	R. 1903	.05
1503	CLARKE, F. W. The atomic theory	R. 1903	.05
1504	LE BON, GUSTAVE. Intra-atomic energy	R. 1903	.05
1505	WRIGHT, J. The electric furnace	R. 1903	.05
1506	GIBSON, G. H. High-speed electric interurban railways	R. 1903	.05
1507	GRADENWITZ, ALFRED. The Marienfelde-Zossen high-speed electric railway trials	R. 1903	.05
1508	WATERHOUSE, J. The beginnings of photography.	R. 1903	.05
1509	LAPWORTH, CHARLES. The relations of geology..	R. 1903	.05
1510	CREAK, E. W. Terrestrial magnetism in its relation to geography	R. 1903	.05
1511	BROOKS, A. H. An exploration to Mount McKinley	R. 1903	.05
1512	PEARY, R. E. North polar exploration, 1898–1902.	R. 1903	.05
1513	MARKHAM, C. R. First year's work of National Antarctic expedition	R. 1903	.05
1514	NORDENSKIÖLD, OTTO, *and others.* The Swedish Antarctic expedition	R. 1903	.05
1515	COOK, O. F. Food plants of ancient America	R. 1903	.05
1516	COVILLE, F. V. Desert plants as a source of drinking-water	R. 1903	.05

1517	Dastre, A. A new theory of the origin of species.	R. 1903	.05
1518	Anthony, M. The evolution of the human foot..	R. 1903	.05
1519	Gill, Theodore. The name "Mammal" and the idea expressed	R. 1903	.05
1520	Vaschide, N. *and* Rousseau, P. Experimental studies on the mental life of animals	R. 1903	.05
1521	Coupin, Henri. Animals that hunt	R. 1903	.05
1522	Chapman, F. M. Flamingoes' nests	R. 1903	.05
1523	Kirkaldy, G. W. Upon maternal solicitude in Rhynchota and other nonsocial insects	R. 1903	.05
1524	Forel, A. The psychical faculties of ants and some other insects	R. 1903	.05
1525	Schiött, Jul. Musk oxen in captivity	R. 1903	.05
1526	Herz, O. F. Frozen mammoth in Siberia	R. 1903	.05
1527	Racovitza, E. C. Spouting and movements of whales	R. 1903	.05
1528	Symington, Johnson. Problems arising from variations in the development of skull and brain.	R. 1903	.05
1529	Meyer, A. B. The antiquity of the lion in Greece.	R. 1903	.05
1530	Wiedemann, A. The excavations at Abusir, Egypt	R. 1903	.05
1531	Messerschmidt, L. The ancient Hittites	R. 1903	.05
1532	Thomas, Cyrus. Central American hieroglyphic writing	R. 1903	.05
1533	Holmes, W. H. Traces of aboriginal operations in an iron mine near Leslie, Mo	R. 1903	.05
1534	Tsybikoff, G. Ts. Lhasa and Central Tibet	R. 1903	.05
1535	Stein, M. A. A journey of geographical and archeological exploration in Chinese Turkestan.	R. 1903	.05
1536	Neumann, Oscar. From the Somali Coast through Ethiopia to the Soudan	R. 1903	.05
1537	Brinkley, F. Primeval Japanese	R. 1903	.05
1538	Hulbert, H. B. The Korean language	R. 1903	.05
1539	Burr, W. H. The Republic of Panama	R. 1903	.05
1540	Newell, F. H. The Reclamation of the West...	R. 1903	.05
1541	Durand, W. J. Robert Henry Thurston	R. 1903	.05
1542	Reich, Emil. Theodore Mommsen	R. 1903	.05
1543	Browning, Philip E. Index to Gallium, 1874–1903	M.C. XLVI	.05
1544	Browning, Philip E. Index to Germanium, 1886–1903	M.C. XLVI	.05
1545	Annual Report of the Smithsonian Institution, 1902–1903	R. 1903[1]	1.00
1546	Annual Report of the Smithsonian Institution, 1902–1903, Part 2, National Museum (*In press*).	M.R. 1903	
1547	Langley, S. P. Report of Secretary, Smithsonian Institution for 1903–1904	R. 1904	.10

[1] For sale by Superintendent of Documents, Government Printing Office, Washington, D. C.

1548 Smithsonian Miscellaneous Collections (*Quarterly Issue*), vol. XLVII, Part 3 (containing Nos. 1549–1558)	M.C. XLVII	.50
1549 ROCKHILL, W. W. Inquiry into the population of China (*Quarterly Issue*)	M.C. XLVII	.05
1550 WHITE, DAVID. The seeds of Aneimites (*Quarterly Issue*)	M.C. XLVII	.10
1551 SHERBORN, C. D., *and* RICHMOND, C. W. Birds in Vroeg's Catalogue (*Quarterly Issue*)	M.C. XLVII	.05
1552 GILL, THEODORE. The Sculpin and its habits (*Quarterly Issue*)	M.C. XLVII	.10
1553 SCRIPTURE, E. W. Report on construction of a vowel organ (*Quarterly Issue*)	M.C. XLVII	.05
1554 JAMBUNATHAN, N. S. Habits and life history of social spider (*Quarterly Issue*)	M.C. XLVII	.05
1555 OBERHOLSER, H. C. Description of a new Sylvietta (*Quarterly Issue*)		.05
1556 MILLER, E. Y. The Tugda or rice planter (*Quarterly Issue*)	M.C. XLVII	.05
1557 WHITE, DAVID. Fossil Plants of the Group Cycadofilices (*Quarterly Issue*)	M.C. XLVII	.05
1558 Notes (including continuation of list of Smithsonian publications from November, 1904, to February, 1905) (*Quarterly Issue*)	M.C. XLVII	.05

THE SMITHSONIAN INSTITUTION

Presiding Officer ex officio.—Theodore Roosevelt, President of the United States.
Chancellor.—Melville W. Fuller, Chief Justice of the United States.
Members of the Institution.—Theodore Roosevelt, President of the United States; Melville W. Fuller, Chief Justice of the United States, Chancellor; John Hay, Secretary of State; Leslie M. Shaw, Secretary of the Treasury; William H. Taft, Secretary of War; Wm. H. Moody, Attorney General; Robert J. Wynne, Postmaster General; Paul Morton, Secretary of the Navy; E. A. Hitchcock, Secretary of the Interior; James Wilson, Secretary of Agriculture; Victor H. Metcalf, Secretary of Commerce and Labor.
Regents of the Institution.—Melville W. Fuller, Chief Justice of the United States, Chancellor; William P. Frye, President pro tempore United States Senate; S. M. Cullom, member of the Senate; Orville H. Platt, member of the Senate; F. M. Cockrell, member of the Senate; R. R. Hitt, member of the House of Representatives; Robert Adams, Jr., member of the House of Representatives; Hugh A. Dinsmore, member of the House of Representatives; J. B. Angell, citizen of Michigan; Andrew D. White, citizen of New York; Richard Olney, citizen of Massachusetts; George Gray, citizen of Delaware; J. B. Henderson, citizen of Washington, D. C.; Alexander Graham Bell, citizen of Washington, D. C.
Executive Committee.—J. B. Henderson, of Washington, D. C.; Alexander Graham Bell, of Washington, D. C.; R. R. Hitt, of Illinois.
Secretary of the Institution.—S. P. Langley.
Assistant Secretary.—Richard Rathbun.
Assistant in Charge of Office.—F. W. Hodge.
Librarian.—Cyrus Adler.
Accountant.—W. W. Karr.
Editor.—A. Howard Clark.
Keeper of Archives.—William J. Rhees.

The National Museum

Keeper ex officio.—S. P. Langley.
Assistant Secretary in charge.—Richard Rathbun.
Administrative Assistant.—W. de C. Ravenel.
Head Curators.—F. W. True, G. P. Merrill, Otis T. Mason (acting).
Curators.—Robert Ridgway, L. Stejneger, F. A. Lucas.
Honorary Curators.—Cyrus Adler, Tarleton H. Bean, A. Howard Clark, F. W. Clarke, F. V. Coville, W. H. Dall, J. M. Flint, Paul Haupt, W. H. Holmes, L. O. Howard, W. L. Ralph, Richard Rathbun, Chas. D. Walcott, J. F. Ward.
Librarian.—Cyrus Adler.
Disbursing Clerk.—W. W. Karr.
Chief of Correspondence and Documents.—Randolph I. Geare.
Superintendent of Construction and Labor.—J. S. Goldsmith.
Editor.—Marcus Benjamin.
Registrar.—S. C. Brown.

Bureau of American Ethnology

Chief.—W. H. Holmes.
Ethnologists.—J. Walter Fewkes, Albert S. Gatschet, J. N. B. Hewitt, James Mooney, Matilda Coxe Stevenson, John R. Swanton, Cyrus Thomas.
Honorary Philologist.—Franz Boas.
Illustrator.—DeLancey W. Gill.

International Exchanges

Acting Curator.—F. W. Hodge.
Chief Clerk.—W. Irving Adams.

National Zoological Park

Superintendent.—Frank Baker.
Assistant Superintendent.—A. B. Baker.

Astrophysical Observatory

Director.—S. P. Langley.
Aid.—C. G. Abbot.

[illegible] PUB. NO. [illegible]

Smithsonian Miscellaneous Collections

[illegible] QUARTERLY ISSUE [illegible]

[illegible] WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
[illegible]

SMITHSONIAN MISCELLANEOUS COLLECTIONS

QUARTERLY ISSUE

The Quarterly Issue of the SMITHSONIAN MISCELLANEOUS COLLECTIONS is designed chiefly to afford a medium for the early publication of the results of researches conducted by the [illegible] and especially for the publication of reports of a preliminary nature. It is not designed that the Quarterly Issue shall supersede the regular series of the SMITHSONIAN MISCELLANEOUS COLLECTIONS, but, [illegible], shall form a part thereof.

Following the long-established custom of the Institution, all contributions submitted for publication in the Quarterly Issue will be referred to [illegible] in whose judgment of the value and suitability of such contributions the [illegible] will be guided.

The Quarterly Issue will be published about the first of January, April, July, and October.

CONTENTS.

VOL. 47 1904

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 2 QUARTERLY ISSUE PART 4

THE DISCREPANCY BETWEEN SOLAR RADIATION MEASURES BY THE ACTINOMETER AND BY THE SPECTRO-BOLOMETER

BY F. E. FOWLE, JR.

(Communicated by S. P. Langley, Secretary of the Smithsonian Institution.)

The object of this paper is to show, that by means of actinometric observations alone, of the intensity of the total solar radiation received at the surface of the earth, we may, by the application of a certain correction, determine the radiation outside the atmosphere with the same degree of accuracy which is reached in a bolographic determination made in Washington by the observation of homogeneous rays.

Mr. Langley demonstrated[1] many years ago that the use of Bouguer's formula with ordinary actinometric observations necessarily leads to too low a value of the solar radiation outside of our atmosphere. This formula may be written $E_x = E_0 a^{m_x}$ where E_x and E_0 are the actinometric readings in radiation units at the air-masses m_x and zero respectively, and "a" the coefficient of transmission of our atmosphere for unit air-mass. The unit air-mass is such that, with the sun in the zenith, the radiation passes through one air-mass or atmosphere to the observer at the surface of the earth.

In employing the formula to compute E_0 from actinometer measures, the error arises from the assumption that the coefficient of transmission "a" is the same for all wavelengths, whereas at Washington the general transmission coefficients may vary from 0.39 to 0.97 (and in water vapor bands may even reach zero), between the wavelengths $0^{\mu}.4$ to $2^{\mu}.0$; beyond these limiting wavelengths the amount of solar radiation is negligible.

[1] *American Journal of Science* (3), XXVIII, p. 163, 1884.

In a paper published by Mr. Langley in the *Astrophysical Journal*,[1] a possible change in the value of the solar radiation was surmised. This possibility is indicated by several kinds of circumstantial evidence:

1. By the spectro-bolographic[2] determinations of the solar radiation by the study of homogeneous rays, thus avoiding the erroneous assumption of uniform atmospheric transmission coefficients for all wavelengths.

2.[3] In several cases by apparent changes in the value of the transmissibility of the solar atmosphere, indicating some change in solar condition coincident with the observed changes in the radiation values determined as just mentioned.

And 3. By observed changes in terrestrial temperature as noted over the greater portion of the northern hemisphere of our earth.

If such changes in the solar radiation actually do take place, then their detection and measurement by some easy and rapid method is of great importance, since the solar radiation is one of the most important factors in determining meteorological phenomena. The bolographic method just mentioned involves not only the use of costly and extremely delicate apparatus requiring two skilled observers, but the subsequent reductions are so laborious that a single reduction requires at least a week's time. The second method, though leading to results with much less time-consuming reductions, yet involves still more costly and quite as delicate apparatus. Hence if some trustworthy method could be determined for computing the so-called solar constant from ordinary actinometric measures, the desired values of the solar radiation could then be obtained not only quickly but cheaply. A secondary actinometer costing probably only $10 or $15 would be good enough for such measures, and indeed as good as any, since all actinometers at present in use must be considered as secondary instruments.

---

[1] *Astrophysical Journal*, XIX, p. 305, 1904.

[2] A full description of the spectro-bolometric determinations may be found in the SMITHSONIAN MISCELLANEOUS COLLECTIONS, Quarterly Issue, Volume I, page 74, 1903. Briefly, solar energy curves are taken at frequent intervals during an afternoon. These serve for the determination of Bouguer's "*a*"s for each wavelength. After an energy curve has been corrected for all instrumental absorptions, it is then, by means of these atmospheric transmission coefficients, corrected to its value outside the atmosphere. The ratio of this final area to that before this last correction, multiplied by the simultaneous actinometer reading, gives the so-called spectro-bolographic determination of the extra-atmospheric solar radiation. This is then reduced to the mean solar distance.

[3] *Nature*, vol. 70, p. 198, 1904.

Actinometric measures, indeed, in common with the bolometric process, depend on the estimation of the transmission of the earth's atmosphere and are at a great disadvantage as compared with the process of observation of the absorption of the solar envelope originally devised by Mr. Langley where, as seems very possible from the solar studies now being carried on here, the changes in the effective emission of the sun itself are determined. In the latter process less than three minutes of constant conditions in our atmosphere are required to make an observation of the apparent absorption of the solar envelope. The actinometric and bolographic processes, on the other hand, demand two or three hour's constant condition of atmospheric transmissibility, which occurs comparatively seldom in such a locality as Washington.

The observations discussed in this paper were made with two actinometers. One was of the Crova pattern, a glass and mercury thermometer, the blackened bulb of which was situated in the centei of a metallic sphere, polished nickel without, blackened within, and having an opening allowing a beam of sunlight of slightly less diameter than the bulb to fall on the latter. The other actinometer was home-made and consisted of a thin flat cylindrical copper receptacle filled with mercury, blackened over the exposed end with platinum black, and the rest nickeled and surrounded by a wooden sphere, bright within, having the beam similarly limited by diaphragms. A mercury thermometer inserted in the copper vessel served to indicate the rise in temperature. Observations are made in the same manner with both actinometers. By cutting the sunlight off from the aperture, a cooling correction is determined for two minutes; the instrument is then exposed to the solar radiation for two minutes, and a final cooling correction for two minutes completes the observation. The radiation value is obtained from the rate of rise during exposure, corrected by the mean of the cooling corrections determined before and after the exposure to the sun. Values of the solar constant have been computed by Bouguer's formula from actinometric measures alone, to see how far short they fall from the spectro-bolometric determinations from the same data.

In this discussion of actinometric measures the observations will accordingly first be treated as if they followed the formula $E_z = E_0 a^{m_z}$ which is better adapted to the purpose in the linear form

$$\log E_z = \log E_0 + m_z \log a$$

where $\log E_z$ and m_z are employed as variables. Thus in order to get a value of the solar radiation at least partly corrected for the absorption in the earth's atmosphere, the observations are plotted with air-masses as abscissæ, and logarithms of the radiation measures as ordinates.

Now the range of air-masses is such that the points thus plotted are very nearly linear, although a slight curvature convex towards

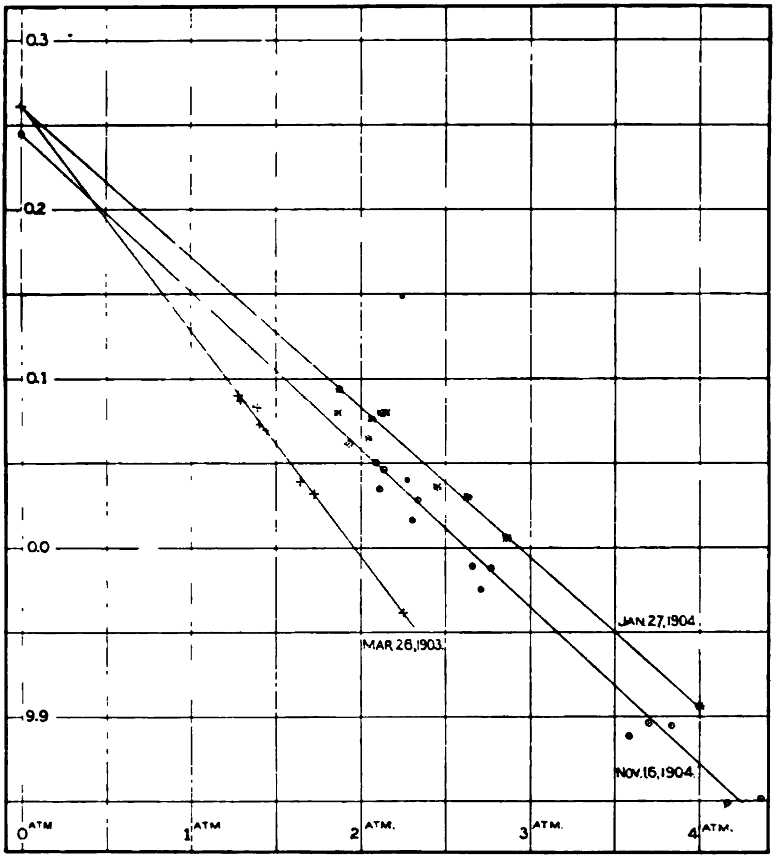


FIG. 62.—Bonguer's Formula and Actinometry of Solar Radiation. Abscissæ are air-masses. Ordinates are logarithms of actinometer measures.

the axis of abscissæ might be expected in accordance with what Mr. Langley has shown, and is indeed at times noticeable where the range of air-masses is great. The straight line best representing these points is then drawn and its intersection with the axis of ordinates ($m = 0$) gives a preliminary too low value of the extrapolated solar radiation.

This process as applied to three different days may be seen in figure 62. The deviations of the observation from the straight line used in the extrapolation are given in Table I and serve as an indication both of the accuracy of the observations and the suitability of the straight line for representing the points.

TABLE I

Logarithmic deviations.

	Mar. 26, 1903.	Jan. 27, 1904.	Nov. 16, 1904.
	0.000	+.002	+.014
	0.000	—.001	—.006
	—0.003	+.003	+.007
	+0.001	—.007	—.003
	—0.002	+.010	—.011
	+0.0007	+.007	+.001
	—0.002	—.002	—.007
	—0.001	—.001	—.013
		(Jan. 27; 3 discordant	+.001
		observations due to	+.007
		passing clouds or	+.001
		smoke are omitted.)	—.012
			+.001
average logarithmic deviation	.002	.004	.006
average deviations	0.5 percent	0.9 percent	1.4 percent

These extrapolated determinations may now be compared with the values of the solar radiation computed by the spectrobolographic method. The results are summarized in Table II.

TABLE II

Date.	Log. a.	a.	Range of Air Masses.	Solar Radiation via Actinometer.	Grade.	Solar Radiation via Bolograms.	Grade.	Percentage Correction Necessary to Actinometer Values.
Oct. 9, 1902	0.113	0.771	1. 5–3.0	1.91	Very good	2.19	Fair	15%
Feb. 19, 1903	0.114	0.769	1. 8–2.9	1.97	Very good	2.27	Very good	15
Mar. 25, 1903	0.148	0.711	1. 4–2.6	1.96	Excellent	2.23	Excellent	14
Mar. 26, 1903	0.133	0.736	1. 3–2.3	1.82	Excellent	2.09	Excellent	15
Apr. 17, 1903	0.126	0.748	1. 2–1.9	1.90	Very good	2.18	Passable	15
Apr. 29, 1903	0.170	0.676	1. 1–1.6	1.75	Bad	1.96	Very good	12
July 7, 1903	0.177	0.665	1.06–1.5	2.07	Short, good	2.14	Poor	3
Oct. 14, 1903	0.107	0.780	1. 6–3.0	1.87	Very good	1.96	Very good	5
Dec. 7, 1903	0.085	0.822	2. 2–3.7	1.69	Excellent	1.94	Passable	15
Dec. 23, 1903	0.077	0.838	2. 2–3.1	1.75	Doubtful	1.99	Passable	14
Jan. 27, 1904	0.090	0.813	1. 9–4.0	1.77	Excellent	2.02	Fair	14
Feb. 11, 1904	0.113	0.771	1. 7–2.9	1.99	Very good	2.26	Fair	14
May 28, 1904	0.121	0.757	1. 1–1.9	1.97	Very good	2.09	Poor	6
Oct. 5, 1904	0.145	0.716	1. 5–2.7	2.02[1]	Very good	2.32[1]	Excellent	15
Nov. 16, 1904	0.095	0.803	2. 0–3.8	1.71	Very good	1.98	Passable	16

[1] Some doubt exists whether these values are not both too high, owing to a possible change in the constant of the actinometer due to an accident.

The first column contains the date of the observation; the second the tangent of the slope of the curve, and is equal to the logarithm of the value of "*a*" in Bouguer's formula; the third, this "*a*"; the fourth, the range of air-masses of the actinometer values; the fifth, extrapolated value of the solar radiation via the actinometer; the sixth, an estimation of the quality of the actinometric series; the seventh the solar radiation via the bolographic process; the eighth an estimation of its quality, and finally in the ninth the percentage correction necessary to bring the actinometer extrapolation in accordance with the bolometric value.

The table shows, as Mr. Langley demonstrated, that the values from the actinometer are too low. It is surprising, however, that the correction to be applied seems so nearly the same, averaging about 14 per cent., nearly independently of the transparency of the air or from what air-masses the actinometer extrapolation is made.

There are but three notable exceptions to this in the table: of these the one of October 14, 1904, is undoubtedly caused by a defect in the latest actinometer value. The other two are extrapolated from very small air-masses where, as will be shown, smaller corrections are to be expected, but besides this the bolographic observations were poor on these latter dates, and in the case of July 7, 1903, too small a range of air-mass was available to suitably determine the extrapolation.

Referring again to the remarkable and unexpected uniformity of the differences between the actinometric and bolometric extrapolations, it seems desirable to see how far this uniformity accords with what theory would lead us to expect. The analytical discussion, however, becomes very complex except in some comparatively simple hypothetical cases, so that the following graphical method has been employed. By the same process used in the bolometric extrapolations, actinometric values may be computed for any desired air-masses. In the accompanying figure 63 are shown two curves thus derived. Curve (A) was computed for March 25, 1903, a day of comparatively great general absorption, and curve (B) for October 14, 1903, a day of small general absorption, but both days of moderate water-vapor absorption. The abscissae are of course air-masses, the ordinates are the logarithms of the computed actinometer readings. It would have been better to have used more extreme cases, *e. g.*, a day of great general and great water-vapor absorptions, together with one when the absorptions of both these kinds were small. Such days, however, were not available. The values of "*a*" for these days as varying with the wavelength are given in Table III.

TABLE III

Percentage Transmission for Vertical Rays.

Date.	μ 0.40	μ 0.45	μ 0.50	μ 0.60	μ 0.70	μ 0.80	μ 0.90	μ 1.0	μ 1.2	μ 1.6	μ 2.0
Mar. 25, 1903,	47	50	57	66	72	76	79	81	84	88	89
Oct. 14, 1903,	64	70	76	80	85	88	89	91	91	(92)	(92)

These curves given in figure 63 show what the actinometer should have read according to the bolographic observations. With air-mass

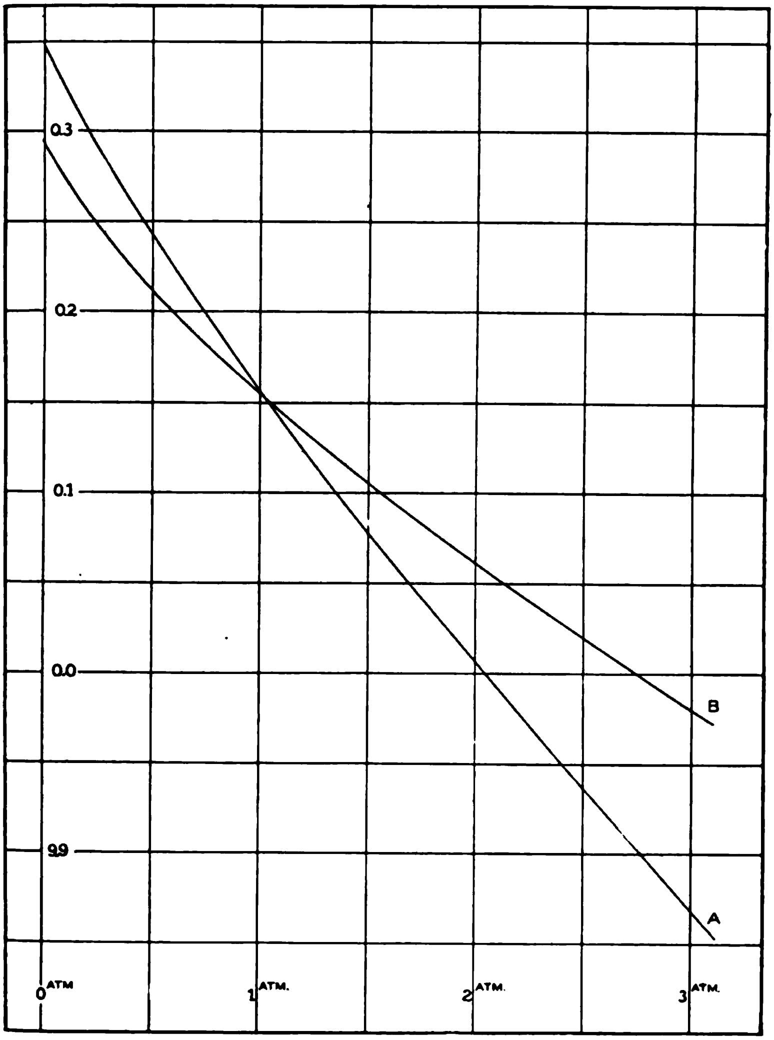


FIG. 63.—Curves of Solar Radiation computed from Spectro-bolometric Measures. Abscissæ are air-masses. Ordinates are logarithms of radiation.

1.0 the value is what would have been obtained with the sun in the zenith, but the points for air-masses between 1.0 and zero are purely hypothetical and do not exist in nature. That is, the point at air-mass 0.5 is not what the actinometer would have read had it been carried above the earth vertically until half the atmosphere lay below it, for such a value we have not the means of computing. It is the radiation that would be observed after passing vertically through a column containing one-half the actual absorbing medium, but with the same distribution of densities as actually exist in the zenith section of our atmosphere. In other words instead of removing the *bottom* layers in order to diminish the air-mass below unity a portion of *each* layer is imagined removed.

An inspection of this plot shows at once several points which Mr. Langley pointed out.[1]

"(1) that the coefficient of transmission" (which is the anti-logarithm of the tangent to the curve) "is not constant; (2) always too large under any circumstances; (3) always larger and larger as we approach the horizon, and (4) *that the original energy of the sun or star before absorption, as found by the thermometric processes and formulae in universal use, is always too small.*" Also that the rate at which the tangents change becomes less and less the greater the air-mass.

Extrapolations, similar to those performed with the actual actinometry, have been made from the computed curves of figure 63. In the following table are given the corrections thus determined, together with "log a" and "a," as found from the slope of line used for extrapolation.

Range of Air Masses Used for Extrapolation.	Log *a*	*a*	Correction.	Log *a*	*a*	Correction
	1.0–1.5			1.5–2.0		
Mar. 25.	.157	.697	9 %	.142	.721	13 %
Oct. 14.	.098	.798	10	.092	.809	13
	2.0–2.5			2.5–3.0		
Mar. 25.	.139	.726	15 %	.137	.730	16 %
Oct. 14.	.085	.822	17	.082	.828	19

It thus appears that in extrapolation from ordinary air-masses varying from 1.5 to 2.5, a correction of 14 to 15 percent *would* be expected.

It is apparent from the table that the *air-masses* from which the extrapolation is made is an important consideration; the smaller the

[1] *American Journal of Science* (3), XXVIII, p. 163, 1884.

air-mass the smaller the correction. However the greater the air-mass, the straighter becomes the actinometer curve and therefore the less the variation in the correction as a function of the air-mass. On the other hand it is to be noted that the correction is not much affected by quite a considerable change in the transmissibility of our atmosphere. It might seem, *a priori,* that the amount of water-vapor present in the air would be an important factor; a small amount of aqueous vapor corresponding with a smaller correction; nevertheless the value of the correction derived from February 19, 1903, a day of phenomenally small water-vapor absorption, does not bear this out. Further study seems, however, necessary on this point.

It would be depending too far on the accuracy of the curves shown to use them as a basis for the determination of secondary corrections like those for changes in water-vapor absorption or general transmission coefficients. It seems apparent from the earlier table of comparisons, however, that in extrapolating from such air-masses (1.5–2.5) as are generally involved, a correction of 14 percent should be added to the resulting actinometer value. This corrected value then would probably be of nearly the same order of accuracy as if bolometrically determined.

For other places of the same altitude as Washington, and where the air-masses used would be nearly the same, it seems very probable that the same correction might apply, provided the transmissibility of the air was within the limits examined here.

For places of greater altitude the correction, although in all probability much smaller, might possibly be more variable.

In order to extend the scope of actinometric observations the actinometer in use here may be compared with several of the Ångstrom type in use at the Weather Bureau, and from this the comparison may be extended to other stations in this country and elsewhere supplied with Ångstrom pyrheliometers. Thus the value of the radiation in units comparable with those used here, may probably be determined for other and perhaps earlier days than those here included. As the correction may be assumed constant for all stations in or near Washington, any actinometer observations made in this locality may serve to determine the correction at other places where simultaneous observations have been made.

It should be borne in mind that the determinations here are not regarded as absolute but are only relatively comparable among themselves. The great variation in actinometer readings at different places and by different instruments is probably often due to the difficulty of reducing their readings to an absolute scale of units. So that although the readings with two different instruments may seem discordant, yet all the readings with each instrument may be relatively quite comparable. While it is much to be desired that a uniform and if possible an absolute system of actinometry should be generally adopted, yet from the conclusions reached in this paper, it appears that even now any good series of actinometric observations on record may be possibly reduced to yield values proportional to the bolometrically determined ones, and all these may later be brought to a common system.

Mr. Abbot hopes soon to have his continuously recording standard actinometer in operation, and it was for use with this instrument that this research was undertaken, and I wish to express my obligation to him here for his continuous help and suggestions in preparing this paper.

CONCLUSION

By the application of a definite empirically determined correcting factor, the use of Bouguer's formula with actinometer measurements alone may serve to determine the extra-atmospheric value of the solar radiation with nearly the same accuracy as by the bolometric method. This correction for Washington is about 14 percent, additive, when the observations are between the air-masses 1.5 and 2.5.

It seems probable that the same correction would be applicable at other stations having, 1st, nearly the same altitude; 2d, similar air-masses, and 3d, similar atmospheric transparency,—this latter condition being determinable by the slope of the actinometer curve.

It is hoped that the correction may be later more accurately determined both as a function of the air-mass as also of the coefficient of atmospheric absorption, and that it may even be extended to places of much higher altitude.

SMITHSONIAN ASTROPHYSICAL OBSERVATORY,
January 21, 1905.

HELICOSTYLA MEARNSI BARTSCH

A NEW PHILIPPINE LANDSHELL

By PAUL BARTSCH

The United States National Museum in a recent consignment of natural history specimens, collected by Major Edgar A. Mearns, U. S. A., in the Philippine Islands, received among other things a beautiful *Helicostyla* which appears to be undescribed. It comes from Mt. Apo, Mindanao, and was collected at an altitude of about 5,000 feet, July 10, 1904. It gives me pleasure to name this shell in honor of Dr. Mearns.

HELICOSTYLA MEARNSI new species

(PLATE LVI)

Shell ovate-conic, imperforate, thin, translucent. Nuclear whorls one and one-half, well rounded, without sculpture. Post-nuclear whorls three and one-half, shining, moderately rounded, marked by many very fine lines of growth and still finer closely spaced spiral lines. The summits of the last and the penultimate whorls are closely appressed to the preceding one. Summit of the last whorl gradually and evenly deflected to about two millimeters below the slightly angulated periphery behind the peristome. Aperture large, oval, oblique, provided with a moderately thickened and reflected peristome; columella moderately broad, irregularly curved, with an irregular, well impressed, median groove extending from the insertion to the base; parietal wall covered by a very thin callous. Coloration: nucleus white, post-nuclear whorls malachite green posterior to the periphery of the last whorl, the intermediate regions between the nucleus and the last whorl more or less evenly graded between these two colors; base chromium green with three somewhat interrupted chrome yellow spiral bands which are bordered on each side by a faintly incised spiral line, the anterior one, on the middle of the base, is the broadest, two millimeters wide, the posterior one marking the periphery with its posterior border is one millimeter wide, the third is a mere line and lies half way between the other two; lip and columnella pale rose purple; umbilical region marked by a pale brown area; while the interior of the shell is pale pearly blue.

The shell measures: alt. 33 mm., lat. 25.5 mm.; aperture alt. 19.6 mm., lat. 15 mm. It is entered as number 180896 in the registration book of the Div. of Mollusks U. S. N. M.

A NEW SPECIES OF FERN OF GENUS POLYPODIUM FROM JAMAICA

By WILLIAM R. MAXON

Among the ferns collected in Jamaica by the writer in 1904 is a simple-leaved *Polypodium* which is distinct from the several related species of middle America. It may be known as

POLYPODIUM NESIOTICUM new species

Rhizome suberect, about 1 cm. long, densely clothed with closely appressed imbricate lanceolate dull light-brown scales: fronds few, approximate, 15 to 22 cm. long; stipe relatively very short (1 to 2 cm. long), densely beset with slender spreading rigid reddish hairs; lamina (largest) 20.5 cm. long, 0.9 cm. broad, bright green, firm, moderately thick, linear-lingulate, rather blunt at the apex, attenuate and decurrent at the base, the under surface sparsely hairy, the upper surface glabrate, the margins regularly marked by broad shallow undulations, ciliate; midvein apparent on the under surface nearly throughout, on the upper surface concealed by the parenchyma except towards the base; venation free, the oblique veins for the most part alternately 3 to 5 times forked; sori round, either terminal or dorsal, wholly superficial, 2 to 4 to each group of veins, irregularly disposed in two or four interrupted rows.

JAMAICA.—Founded upon a single specimen, U. S. National Herbarium, no. 520770, from the vicinity of Vinegar Hill, altitude 1200 meters; William R. Maxon, no. 2773; June 23, 1904. Growing upon the trunk of a forest tree, ten feet from the ground.

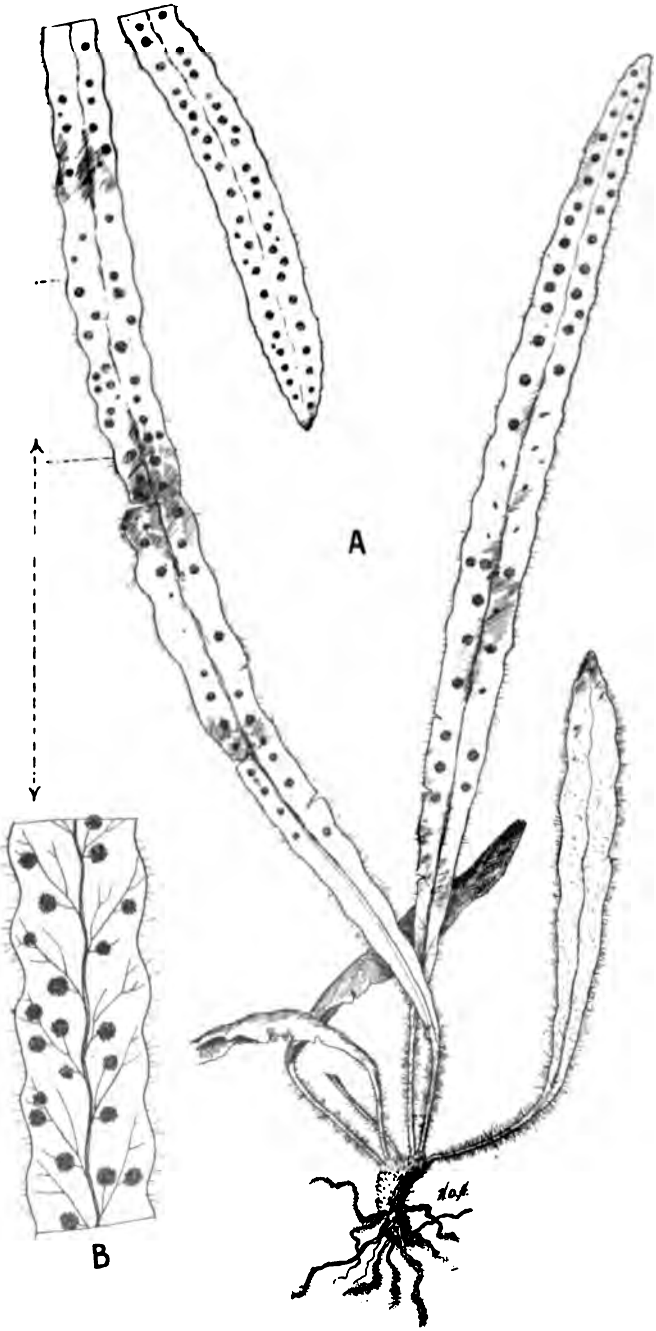
The present species appears to be a very rare member of a group of tropical American species represented in Jamaica by the well known *Polypodium trifurcatum* L., *P. fawcettii* Baker,[1] and *P. dendricolum* Jenman,[2] the last apparently very close to the Colombian *P. parietinum* Klotzsch.[3] *P. fawcettii* and *P. dendricolum* have been well distinguished by Jenman[4] since their original publication.

[1] *Journ. Bot. Brit. and For.* 27: 270. 1889.

[2] *Gard. Chron.* III. 16: 467. 1894.

[3] *Linnæa* 20: 373. 1847. Illustrated by Kunze, Farrenkr. 2: 41. pl. 117, f. 1. 1848–1851.

[4] *Bull. Bot. Dept. Jamaica* II. 4: 68–69. 1897.



POLYPODIUM NESIOTICUM MAXON

A. — Entire plant, natural size.

B. — Section of large frond to show venation, twice natural size

P. nesioticum is very distinct from both, but for the benefit of those who have not material of these rare species the following notes may be of use.

P. fawcettii is correctly said by Jenman to be "infrequent at 4,000 to 6,000 feet altitude in damp forests on the trunks and branches of trees." Two numbers (2723, 2760) were collected in such situations by the writer in 1903 and 1904. It is characterized, briefly, by its dark villous slender conspicuously upright rhizome, numerous closely set small, very narrow fronds, and almost simple veins,—the sori being borne in two rows near the midvein, each upon a short spur given off by the otherwise simple vein. In all these characters the plant contrasts strongly with *P. nesioticum*.

P. dendricolum appears to be a very rare species. Professor Underwood states (*in. litt.*) that it is "represented at Kew only by a tracing of the type," the type being presumably in the Herbarium of the Jamaican Botanical Department at Kingston, Jamaica. There is, however, a single frond from the type specimen preserved in the Jenman herbarium at New York, and this agrees absolutely with two other numbers of Jamaican specimens, *viz.*: one (without definite locality), collected by D. E. Watt in 1903; and another, from the slopes of Monkey Hill (above New Haven Gap), altitude about 1,800 meters, Maxon, no. 2736; both of which numbers are represented in the herbarium of the New York Botanical Garden and the U. S. National Herbarium. This species is somewhat more closely related to *P. nesioticum* than is *P. fawcettii*. It is distinguished by its reduced stature (5 to 7 cm.), thicker texture, more general villous covering, deeply scalloped (instead of undulate) margins, simpler venation, and particularly (1) by having the midvein covered on both surfaces by parenchyma, and (2) by what Jenman calls "embossed receptacles," *i. e.*, having the parenchyma considerably raised (on the under surface) above the concealed veins toward their extremities, thus imparting a marked rugose effect to the under surface. The last character is sufficient in itself to distinguish *P. dendricolum* at sight.

The venation of *P. nesioticum* is peculiar and shows an approach to that of *P. trifurcatum*. It is well indicated in the accompanying plate which has been prepared under the author's supervision by Mr. H. D. House.

CONTRIBUTIONS OF AMERICAN ARCHEOLOGY TO HUMAN HISTORY[1]

By W. H. HOLMES

Not wishing to weary the Congress with the reading of a lengthy paper, I shall attempt to give the substance of what I would say in brief outline, but in the beginning, as the representative of the Smithsonian Institution, I have the honor to present to the Congress a set of publications to be disposed of as it may deem expedient. These volumes, about sixty in number, are selections from the archeological publications of the Institution and two of its bureaus—the National Museum and the Bureau of American Ethnology. They deal almost exclusively with the problems of primitive American history and prehistory and mainly with the aboriginal history of the extensive region now comprised within the United States. Most of the volumes were published under Government auspices, largely in the annual reports of the Bureau of American Ethnology, of which Major J. W. Powell was the founder and the guiding spirit.

The Bureau's work extends over a period of twenty-five years, but the parent institution began the publication of archeological material almost from its foundation, the first number of its great series of contributions to knowledge having been the "Monuments of the Mississippi Valley," by Squier and Davis, a work known and esteemed by Americanists everywhere. The works here presented comprise only the more important papers relating to this branch issued by the Institution and form but a fraction of its anthropological publications, a complete list of which includes several hundred titles. I have the honor also to present a set of photographic portraits of American Indians made during the past winter by the photographers of the Bureau of American Ethnology and the National Museum, representing members of the various delegations of the natives visiting Washington on business growing out of their relations with the Government. The portraits, about sixty in number, represent upwards of twenty tribes, front and profile views of each individual being given. Besides the portraits, physical meas-

[1] Read before the Congress of Americanists, Stuttgart, Germany, August 21. 1904.

urements were taken of all, and masks were made of such as could be induced to undergo the unpleasant ordeal.

What I now desire to say does not have to do with what American archeologists or the American Government have done for archeological science, but rather with what prehistoric America has contributed and may be expected to contribute in the form of materials of human history.

The importance of archeology to the student of history is now fully recognized. The science is establishing its claims to consideration more fully year by year, especially since it has become allied with geology, which furnishes the necessary time scale, and with paleontology, which supplies the scale of life. The branch of inquiry which only a few years ago dealt with isolated fragments of knowledge, with disjointed parts of the framework of human history, now essays to aid in building up the entire skeleton of that history, and, with the aid of the allied sciences of ethnology and psychology, in clothing it with the integuments of a living reality.

America is taking a noteworthy part in this rehabilitation of the race and, fortunately, is most helpful just where the Old World is weakest. In America the past of man, for the most part at least, connects directly with the present and with the living. Each step backward along the course of culture development proceeds from a well established and fully understood base, and there is thus no baffling gap between history and prehistory, as in the Old World.

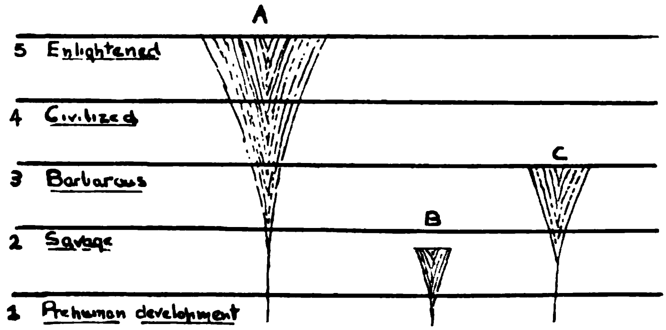
In America all the steps of culture, from the highest to the lowest, within the native range, are to be observed among the living peoples, and we are thus able to avoid many of the snares of speculation with respect to what men have thought and men have done under the greatly diversified conditions of primitive existence.

In America the conditions are simple. The antiquities of a region represent in a large measure the early history of the known peoples of that region. There have not been the successive occupations, the racial interminglings, the obscuring and obliteration of phenomena that so seriously embarrass the student of the ancient nations of the Old World. The stone age and the red race stand practically alone within the field of study.

In America the high-water mark of culture barely reached the lower limit of civilization. In the Old World the representation of man's career is fuller above than below that limit, so that America can be expected to assist, especially, in building up the substructure of human history; it can be expected to furnish a fuller reading of the early chapters of culture progress than any other part of the world.

The position of aboriginal America in the field of culture history and the area of that history which American archeology, as well as American ethnology, can be expected to illumine is clearly indicated in the accompanying diagram.

In this diagram the whole field of human history is represented by the five spaces which, beginning below, are: (1) the stage of prehuman development through and out of which the race arose; (2)



the savage stage in which humanity took definite shape; (3) the barbarous stage in which powerful nations were founded, and systems of record were developed; (4) the civilized stage in which higher culture was achieved, and (5) the enlightened stage, reached as yet only by a limited number of nations. The idea of time is not involved in this diagram. The stages of progress thus become a scale on which the cultural achievements of any race or people in its struggle upward may be laid down. It enables us to show just what relative place is taken by each race or people and just how much and at what points each can contribute to the history of man; for human history as written is composite, made up of the separate histories of many peoples of all grades of development set together like a mosaic.

The fan-shaped figure, *A*, in the diagram, may be taken to express the history of the race, that is, the whole of human progress from the slender beginnings of the savage stage up to its greatest expansion at the present day. The same figure may stand with equal propriety for the career of a single people or nation that has reached the highest limit of culture. In the diagram, the beginnings of cultural development are represented at the base of the figure by a few slender threads of activity. In savagery these threads multiply slowly into a considerable number and, with ever accelerated rapidity, divide and subdivide in barbarism and civilization, expanding with marvelous rapidity in the horizon of enlightenment. While this expanding figure may be regarded as expressing the growth of human culture, it may also symbolize the development of the race in population and in physical perfection.

The figure indicated by *B* may stand for the career of peoples of the lowest existing order of culture, such as the Fuegians or Andamanese—peoples which can contribute to general history only within a very limited range, since their career traverses only the lower half of the field of savagery. It is to be noted, however, that these lowly peoples can contribute much more fully to the history of this particular stage of progress than can any of the nations that have passed this stage and have arisen to higher levels.

The field covered by the American race is outlined in *C*. Uncertain and indefinite in the beginning stages, the traces being hardly legible on account of the absence of written records and the insufficiency of archeological research, it develops upward, stopping just short of the level of civilization. Many strands of culture had appeared and grown strong, but writing had not been fully achieved and other arts peculiar to civilization had not made their appearance. It is within this field that Americanists pursue their studies and make their contributions to the history of the race and of developing civilization. Above this stage they find nothing and below it only meager and uncertain traces of the beginning stages of human culture. The archeologist finds within this limited American field, however, extensive phenomena relating to the various branches of barbarian activity, especially to such as leave their traces in material form. Prominent among these branches are agriculture, hunting, fishing, quarrying and mining; the shaping of implements and utensils; the building arts, metallurgy, sculpture, ceramics, the textile arts, the graphic arts and writing, war, games, culinary arts, religious arts, personal adornment, the decorative arts, etc. These groups of phenomena as exhibited in America have been the subject of earnest study by a large number of scholars, and already a great body of data relating to them has been collected and an extensive literature is in existence. A few of the more instructive of these groups may be briefly reviewed.

Quarrying and Mining.—Much of the history of the activities concerned with the acquisition of the raw materials of subsistence and the arts is best studied among existing peoples. This is especially true of hunting and fishing, the gathering of wild fruits and grains, and agriculture; but archeology alone can be depended upon to tell the story of the industries concerned with developing the mineral resources. These activities escaped the observation of the conquerors and colonists, and were discontinued so abruptly that very meager records of their operation have been preserved. The story of the struggles of primitive man in exploiting the valleys and mountains and in extracting the staple materials of the stone age from their rocky beds forms one of the most interesting and important chapters in the history of incipient civilization. With only stone, bone, and wooden implements the aborigines attacked the massive strata, breaking up solid bodies of flint, quartz, obsidian, jasper, etc., for the manufacture of implements and carving out huge monoliths from the living rock for building and sculpture. A study of the American mines and quarries gives us a vivid conception of the strength and persistence of the forces that underlie human development and of the difficulties encountered by the race in carrying culture upward through the stone age to the higher level of the age of metal. The shaping of the stone into implements and utensils supplemented the work of the quarrymen, and the story of the development is clearly told in many lands, but America's contributions to the history of this most important branch of activity are exceptionally full and satisfactory.

Architecture.—Aboriginal architecture in America teaches the lessons of the initial development of this branch of culture with exceptional clearness, beginning at the lowest stage and carrying it up to about the stage of the keystone arch. The present period affords a wide range of phenomena representing the elementary forms of building, and the post-Columbian chronicles give us somewhat meager glimpses of the higher development that came under the observation of the Spanish conquerors, whilst archeologic remains supplement the lessons of the historic period. We find constructions of great variety and of remarkable preservation in the Mississippi valley, in the Pueblo country, on the Mexican plateau, in Yucatan, Guatemala, and Honduras, and in South America. By the aid of these we see how the midden and the earth mound develop into the pyramid with its multiple stairways of cut stone; how the walls change from irregularly placed stone and clay-covered wicker to massive structures of accurately hewn stone; how the chamber spaces, ceiled at first with weak timbers subject to quick decay, are spanned later by the offset arch of stone. We see supported on this native arch the concrete roof, so massive as to defy the earthquake and support the forest growth of succeeding centuries; we see the multiplication of stories, tier on tier; we see the spanned space, limited at first to a few feet, increase indefinitely to the many-vaulted roof supported by a wilderness of limestone columns; we see walls decorated within and without with symbolic sculptures, single buildings presenting thousands of square yards of embellished surface, and marvel at the lofty false fronts and roof crests that were added to afford space for the exercise of the native genius for decoration.

These chapters in the evolution of the building arts are not taught with equal clearness and fullness in any other part of the world. Besides those direct lessons which bear upon the history of the art of architecture many side lights are thrown upon other branches of primitive culture, as mural decoration, sculpture and furnishing, as well as upon the organization of society, religious beliefs, and systems of glyphic writing.

Sculpture.—Sculpture reached its highest development in Greece, but the stages through which the art passed are but meagerly recorded in extant art works of Hellas. The earlier steps are represented by isolated bits in many places, but the primitive phases of the art are by no means so fully exhibited as they are in America. We have there a vast body of material covering every stage of stone-shaping from the very beginning up to full relief and realistic portrayal of the human subject. No people known to us has within the culture range of the Americans shown such versatility and power with the hammer and chisel, none that has embodied in stone a mythology so rich in imagery, including as it does forms of men, beasts, monsters, and cosmic phenomena in greatest variety. The archeologist has here spread out before him as in an open book, with the work of the living peoples to guide him, the whole story of the evolution of sculptural phenomena within the horizon of barbarism.

Metallurgy.—The working of metals is among the most important activities of civilized man and has been a chief agency in the development of culture, as is especially manifest in the gigantic forward steps of recent years. Although the general course of metallurgic development and the mutual relation of its successive stages of progress are well made out, much remains to be learned, and in this direction America is able to make the most valuable contributions. We learn from history something of the metal work of the American aborigines. Tin, lead, and iron were little known, and the smelting of ores was in its infancy, but gold, copper, and silver were extensively used when the Spaniards arrived, and these metals were forged, fused, cast, alloyed, plated, and otherwise handled with a skill that astonished the conquerors. Archeology verifies the statements of historians and adds much to our knowledge of the manipulation of metals and of the products in the primitive stages of culture, not only in regard to the Western continent but for the general history of the subject at periods where the records in the Old World are most defective.

Ceramics.—Of art in clay we may say much the same as of sculpture. No people known to us has furnished such a vast body of material for the study of this art from its beginnings up to the level of glaze and the wheel as have the pre-Columbian Americans. The clay took on a multitude of forms in which were embodied a wide range of mythologic and esthetic concepts.

The Graphic Arts.—To the history of writing aboriginal America makes many contributions, and these, as the others referred to, within that part of the history of progress wherein Old World evidence is least satisfactory. In the Old World we trace back the history of writing step by step to a point near the beginning of the glyphic system; in the New World we pass back from the lower margin of the glyphic to the very beginning of the graphic, thus all but completing the history of the evolution of the recording arts.

With a knowledge of the present and prehistoric phases of picture writing it is easy to utilize and interpret the vast body of material in this branch furnished by archeology; but, rich as is this material, insufficient light is thrown upon the transition from picture writing to phonic writing, the particular stage of development in which archeologists find one of the most fascinating fields of research. The great body of evidence brought before the conquering Europeans was not appreciated by them, but rudely destroyed, and the remains, graphic and sculptural, are now being gathered together and studied in the most painstaking manner by our scholars, who hope almost against hope to find a key to the problems of transition. Within the cluster of graphic phenomena which gave birth to writing we have evidence bearing upon other important branches. We here get glimpses of the history of the calendar; we find traces of the pictorial art, which had not yet reached the stage of light and shade, perspective, and portraiture, and discover many germs of embellishment, mythologic and esthetic.

Although many of the obscure problems arising in this American field have been successfully worked out, many others are still awaiting the attention of Americanists and will no doubt yield, little by little, to their persistent efforts.

The more important unsolved problems of aboriginal America are those of race origins, of culture origins, and of chronology. These problems do not relate so much to particular nations as to the history of the race as a whole; not so much to peculiar or local cultures as to the origin and evolution of the native activities; not so much to tribal or national chronology as to correlations of race and culture history with the geological time scale.

With respect to race and racial characters American archeology has as yet little to add to what may be learned from studies of the living peoples. So far as observed, the variations in type of fossil forms do not extend decidedly beyond the range of variation observed among the living. It has been sought to establish a paleo-American type in South America, but we are not certain that a sufficient comparative study of the osseous remains of the present peoples of the world has been made to warrant a satisfactory determination. Conservatism is especially desirable in any attempt to establish new racial types or special orders of culture.

Regarding race origin it may be said that there is still room for speculation. Opinion seems, however, to be settling down to the view that the American race, as it stands to-day, is not autochthonous but is an offshoot of Asiatic peoples, originally more or less diverse in character, arriving in America, mainly at least, by the Bering strait route, not abruptly, but in the normal course of race distribution from a natal habitat, the migration continuing for untold centuries. Americanists have here a difficult, a perplexing, but a most fascinating field of research.

To-day, one of the most absorbing questions encountered by the student of American archeology is that of the *origin of the aboriginal cultures*. Some regard these cultures as autochthonous; others have looked for their source in many different parts of the world. Although no final conclusion can yet be announced, we may assume that, along with the incoming peoples, all or most of whom must have been extremely primitive dwellers of the far north, there came the simplest forms of the arts of hunting, fishing, shelter-building, and the preparation of food; that from these elements, under the influence of more southerly environment, there arose in time diversified culture groups, such as are now under investigation in various parts of the continent. We can not but admit, however, the plausibility of the theory that seafaring wanderers from other lands have now and then reached American shores, bringing with them the germs of distinct cultures, and further, that the characteristic art phenomena of certain centers of progress are such as to give countenance to this idea. This is a most interesting and important branch of archeological research, and one with which archeologists must at this stage particularly concern themselves.

Archeology furnishes a vast amount of interesting data regarding the *states of culture* of the American race, but we note that in all the researches so far conducted no traces of culture phenomena have been found which extend below, on the one hand, or above, on the other, the range observed among the living or historic tribes. There is nothing so unique that it might not belong to known tribes or their immediate ancestors. It has been sought to differentiate a paleolithic culture and period in America but without tangible result. So far as the use of the terms "paleolithic" and "neolithic" are concerned they may both be omitted from the nomenclature of American archeology without loss, if not to possible advantage. The simplest forms of stone implements occur everywhere in association with the most highly developed forms, and neolithic forms are reported from formations of nearly all periods back to the earliest that have been observed.

In America, especially in North America, we have sought almost in vain to establish a definite *chronology* of man and culture. Evidence of antiquity is not wanting, but when we try to adjust the phenomena to the geological time scale we meet with indifferent success. Hundreds of ancient caves have been searched, with only negative results; glacial gravels have been examined with great care, but the returns are exceedingly meager; river terraces, and kitchen midden deposits yield nothing of particular value, and the results, when viewed as a whole, instead of enlightening the mind, fill it rather with confusion. It is within the bounds of possibility that this confusion may in a measure be due to the presence in America of an autochthonous race element. The contributions of American archeology in this department are not to be compared with those of the Old World where definite chronological results are forthcoming on all hands. That America may yet furnish contributions of importance in this branch of enquiry, however, lies well within the bounds of possibility.

It is thus seen that there are in America numerous questions awaiting solution, and there is vagueness in many places, but, notwithstanding this, the results of our archeological investigations are on the whole most gratifying; each year the areas of the uncertain and the unknown are being reduced; and when the results achieved are supplemented by the rich materials derived from the study of the living peoples they must go far toward illuminating the pages of the story of humanity in general which the Old World has been gradually but surely revealing.

Viewing the whole field of prehistorical research, we are struck by the fact that the past of man is rapidly disclosing itself to our vision, so that presently we shall be able to look backward through the biological and cultural vistas of his coming and connect the present with the vanishing point of the human perspective with an insight and comprehension little dreamed of until now.

THE BIRDS OF THE GENUS CINCLUS AND THEIR GEOGRAPHICAL DISTRIBUTION

By LEONHARD STEJNEGER

The dipper has always occupied a prominent place in my affection; he was one of the earliest bird friends of my boyhood. Almost as far back as I can remember that cheerful fellow reared his young less than two hundred yards from the house where we used to spend the summers. The dipper's nest was the first bird nest I ever discovered. It was placed under an old stone bridge across a rushing mountain stream where we bathed and fished, just high enough to be out of my youthful reach. The dipper was also the first bird I drew and painted from nature, and curiously enough, when the question as to the various races of the European species arose more than thirty-five years ago, and old Professor Jean Cabanis asked me to get him a specimen for the Berlin Museum, the dipper's was the first bird skin I ever attempted.

Later the highly peculiar and aberrant morphological characteristics of the genus *Cinclus* attracted my attention. As an oscinine bird with the downy covering and diving faculty of a water bird, the dipper certainly is an anomaly, and the various positions given to the genus by the bird classifiers attest how puzzling its relationships are. Even at this late day there is no absolute certainty as to its most intimate affinity. We need not worry about the alleged proximity to such birds as the Motacillidæ, on the one hand, or *Seiurus,* on the other. The timaliine similarities sometimes hinted at may also be dismissed with a light heart. The majority of ornithologists of to-day divide upon the question whether the dipper is more closely allied to the thrushes (Turdidæ in the wider sense) or to the wrens. Twenty years ago I inclined in the latter direction and wrote (Standard Nat. Hist., IV, Birds, 1885, p. 505) that the dipper "in appearance, movements, nest-building, etc., is a gigantic wren." It is certainly true that in these particulars it resembles the wrens sufficiently to make that particular view a tempting one, but on reconsidering the structure I am coming back to Professor Baird's dictum that the "Turdidæ, Saxicolidæ, and Cinclidæ are all closely related to each other by the presence of common characters" (Review Amer. Birds, I, 1864, p. 1). It is well to remember in this connection that Professor Baird placed *Sialia* in the Saxicolidæ, and that in my Remarks on the Systematic Arrangement of the American Turdidæ (Proc. U. S. Nat. Mus., v, 1882, pp. 449–483) I included the Turdeæ, the Saxicoleæ, and the Sialieæ in the same subfamily, Turdinæ. As for the "character which really indicates the relationship of the birds to be included in this family" [Turdidæ] I stated that "the peculiar spotted first plumage of the Turdidæ is a very striking feature, and its coincidence with booted tarsi very remarkable" (*op. cit.*, p. 450). At the time of writing that sentence I was unacquainted with the real primitive style of young plumage which is only shown by some of the Asiatic dippers.

In recent years the problems involved in the geographical distribution of the dippers has again turned my attention to that fascinating group. Its geographical range is certainly quite remarkable. In the Palearctic region—or subregion, if you please—the dippers flourish in most of the high mountain systems, from the Atlantic to the Pacific, and northward it extends into the Arctic life zone whenever mountain chains lead the way. In the New World, however, the dippers are confined to the boreal zone of the long Cordilleran chain from Alaska to the Argentine Republic. They are unknown in Greenland, Labrador, and the whole eastern mountain system. Nor are dippers known from any other mountains in South America but the Andes.

In this connection I have another recantation to make. Owing to our former lack of specimens of the east Asiatic dippers in the first plumage alluded to above I assumed that the white underside of *Cinclus leucogaster* and of the South American species *C. leuconotus* were not only parallel developments, but that the latter represented the primary young plumage which I thought I recognized in the first plumage of *Cinclus cinclus*. In 1885, therefore, I concluded "that the neotropical forms are most like the ancestral stock" and "that South America is the cradle of the genus" (*op. cit.*, p. 505). But as it now turns out, nothing could have been more fallacious.

Since those early days I have seen the young of *Cinclus asiaticus* and *C. pallasii*. They are typically turdine! Both are startlingly like enormous, overgrown fledglings of *Sialia* except that they do not have the blue color on tail and wing-feathers. The first mentioned has all the feathers white with a broad dusky margin giving the whole plumage a distinctly squamate appearance, and the second has the light centers of the feathers of the upper surface suffused with brownish. The combination of the thrush-like spotting with the booted tarsi is complete! Nor is the fledgling plumage of the wheatear (*Saxicola*) very different, except for the white on rump and tail, but these features are plainly secondary developments. The similarity of these young birds is so great that added to the many structural characters pointed out by Professor Baird I am convinced that *Cinclus* has sprung from the same root as the other two, and that its many peculiarities are mere adaptations to its aquatic habits. Even the curious " dipping " motion which in a great measure has helped to associate it in our minds with the wrens, connects it equally well with the Saxicolas.

The latter are exclusively Old World birds except the typical species *Saxicola oenanthe* which I have shown to be a comparatively recent immigrant into this continent (Proc. U. S. Nat. Mus., XXIII, 1901, pp. 473–481). The blue-birds, *Sialia,* on the other hand, are North American. While it is true that they follow the elevated regions down to the isthmus of Panama, it is also true that they have no Neotropical relatives, that they belong to the birds characteristic of the Nearctic region—or subregion! Sharpe has recently affirmed that the beautiful Himalayan bluebird, *Grandala cœlicolor,* tested by the characters I have given for the Turdidæ, " shows great affinity to *Sialia*" (Hand-list Birds, IV, 1903, p. 184), and he even enumerates it between the two nearctic genera *Sialia* and *Ridgwayia* in order to express this close affinity,[1] Sharpe also places the genus *Catharus* in close proximity to the bluebirds. This genus inhabits the elevated portions of Mexico and Central America south into northern South America along the Andes as far as Peru. Nevertheless, it is not a neotropical genus; its affinities are distinctly holarctic whether we adopt Dr. Sharpe's view that they belong to the Sialieæ or mine (Proc. U. S. Nat. Mus., V, 1882, p. 467), that they are part of the same group which includes the Old World nightingales, blue-throats, etc., viz., the Luscinieæ.

Bearing these facts in mind I have therefore no hesitation in affirming that *Cinclus* is of palearctic origin.[2] It remains only to fix upon a more restricted and definite region as its probable original starting point.[3]

[1] Seebohm even placed *Grandala* in the genus *Sialia.*

[2] It will be seen that on the whole I agree with Seebohm, Brit. Birds' Eggs, I, 1883, p. 253, and Scharff, Hist. Europ. Fauna, 1899, p. 255.

[3] It may help to understand the following better if I give a condensed synopsis of the various forms (31) now recognized by advanced ornithologists. No attempt has been made to subordinate them, and their unit names are enumerated chronologically in each main group.

Genus *Cinclus* BORKHAUSEN, 1797

a^1 Coloration of young more or less squamate (Old World).

b^1 Color of adults more or less uniformly fuscous.

Among the Asiatic dippers there appear to be two fairly distinct types, one uniformly dusky when adult and strongly squamate above and below when young, exemplified by *Cinclus pallasii,* and one with some of the underparts pure white, when adult, and with the squamation less pronounced in the young, exemplified by *C. cashmeriensis.* Both of these types meet in the eastern Himalayas radiating thence east, north and west, the uniformly colored forms more easterly, the pied forms more westerly. There will probably be few dissenting voices among those who have followed me thus far, if I designate that enormous and ancient plateau and mountain region north of India and east of the 90° east longitude (including the "Manchurian coign" of the geomorphists, Suess's Eurasian "Scheitel") as the region where the genus *Cinclus* originated. From this center the dippers radiated wherever high enough mountain ranges, or otherwise boreal conditions, permitted them to push forward their colonies.

C. pallasii Temminck, 1815: East Siberia, China, Japan, south to Assam; ***asiaticus*** Gray, 1846: Assam to Turkestan; ***sordidus*** Gould, 1859: Himalayas, North Tibet, Northwestern China; ***marila*** Swinhoe, 1859: Formosa; ***soulici*** Oustalet, 1892: Tibet; ***bilkevitchi*** Zarudny, 1902: Altai Mts.; ***siemsseni*** Martens, 1903: Fokien, China; ***kiborti*** Madarász, 1903: Krasnoyarsk, Siberia; ***middendorffi*** Sushkin, 1904: Sayan Mts., Siberia.

b^2 Color of adults more or less white on underside.

C. cinclus (Linnæus) 1758: Scandinavian peninsula; ***merula*** (Schæffer) 1789: Central Europe; ***gularis*** (Latham) 1801: Great Britain; ***albicollis*** (Vieillot) 1816: Southern Europe; ***syriacus*** Gloger, 1833: Syria; ***leucogaster*** Bonaparte, 1850: from Turkestan eastwards; ***cashmeriensis*** Gould, 1859: Himalaya Mts. westwards; ***minor*** Tristram, 1859: Atlas Mts.; ***pyrenaicus*** Dresser, 1892: Pyrenees; ***baicalensis*** Dresser, 1892: eastern Siberia; ***saturatus*** Dresser, 1895: Baical; ***olympicus*** Madarász, 1903: Cyprus; ***caucasicus*** Madarász, 1903: Caucasus; ***sardus*** Hartert, 1904: Sardinia (and Corsica?); ***bianchii*** Sushkin, 1904: Sayan Mts., Siberia.

a^2 Coloration of young not squamate, more or less like adults (New World).

b^1 Coloration more or less uniform grayish, without white patch on underside of wing (North America).

C. mexicanus Swainson, 1827: Mexico and Guatemala; ***unicolor*** Bonaparte, 1827: Western North America north of Mexico; ***ardesiacus*** Salvin, 1867: Central America.

b^2 Coloration in vari-colored patches; a white patch on underside of wing (South America).

c^1 Color more or less fuscous with white head.

C. leucocephalus Tschudi, 1844: Bolivia and Peru; ***leuconotus*** Sclater, 1857: Venezuela, Colombia and Equador; ***rivularis*** Bangs, 1899: Colombia.

c^2 Color gray with a rufous throat patch.

C. schulzi Cabanis, 1882: Argentina.

Without paleontologic evidence it would be impossible to say with any degree of approximation when this radiation took place, and there is but slim chance that we shall ever have such evidence. However, the indications are that so deep-seated modifications as we have seen that the dippers have undergone, as well as others to be mentioned later on, must have required a comparatively long time for their accomplishment. If I were to make a guess, I should place the origin and beginning of the dispersal of the dippers not later than the dawn of the Tertiary.

Geologists and bio-geographers seem pretty well agreed that at that time the eastern portion of Asia and North America were connected by a land bridge somewhere about Bering Sea, and that a great uplift took place which was the beginning of the mountain ranges which from Alaska southward parallel our Pacific coast. In eastern Asia similar ranges stretch out from the elevated region alluded to above northeastward towards Bering Sea. Along this route it would not have been difficult for the ancestor of our *Cinclus unicolor* to have found his way into western North America.

Before proceeding further it may be well to remark that the ancestral dipper must have been in every respect, both as to structure and to habits, a typical *Cinclus*. Before he left the original home he must have acquired all the peculiarities so characteristic of the genus, since in all these details the most remotely located members of the group are essentially a unit. The species rearing its young on the confines of Patagonia in nearly all particulars, except color, conforms with the one "dipping" on the snow-fells of far away Scandinavia.

All these structural peculiarities and the habits of the bird are strictly interrelated. In other words, as the ancestral dipper had the essential structure of the dippers of to-day, so he also had their habits, and as these again interact with the conditions of life and surroundings, so the ancestral dipper must have inhabited the same life-zone as its descendants. From the latter we are therefore justified in concluding backwards as to the conditions under which the ancestor lived. As the dipper lives to-day so he lived in Miocene times.

It cannot be the purpose in this connection to give an extended account of the interesting habits of these birds, but sufficient should be said to fully explain the conditions necessary to enable the dippers to emigrate into distant lands.

The dipper breeds in the upper portion of the boreal zone, extending upwards or northwards into the arctic-alpine zone, in closest proximity to cold rushing mountain streams. These he follows some distance down into the lower boreal zone, provided the short summer is not too intensely hot. In winter he does not migrate in the regular sense of the word, no matter how cold it is, provided the streams do not freeze over completely. Where they do that he is obliged to go south or down some little distance until he strikes open water, and when once on the move some individual may go astray possibly a few hundred miles, but rarely far away from snow and ice if he can help it. But it is the mountain torrent with its teeming life he loves, and he abhors the sluggish flow of the water courses of the boggy or heavily timbered plains. In this peculiarity we must seek the explanation of the fact that the dipper has never crossed our continent and that the streams of Labrador and the Appalachian mountains do not know him.

It is then evident that in order to emigrate from the plateau of Asia to Alaska there must have been a continuous boreo-arctic life zone occupying a portion, at least, of the hypothetical land bridge across Bering Sea, and this life zone must have furnished in addition the special conditions suited to the dippers' requirements. This life zone stretches across to-day, but the question is whether the climate in Eocene or early Miocene times would not be an insurmountable obstacle in the dipper's way. We have all been told that during that period of the earth's development the climate was much milder than to-day, and moreover, this same land bridge is supposed to have been used by many other animals, inhabitants of a warmer zone than the one to which the dipper is restricted. If therefore this was his route of emigration we must suppose that the land bridge in question possessed a sufficient elevation to provide a suitably cool climate in its higher altitudes. This is a question for the geologists to decide.

That the dipper once on Alaskan soil found mountains sufficiently elevated to suit his tastes is less problematical, and when the uplift of the various systems which go to make up the long chain from Alaska to Patagonia reached its highest limit a continuous boreal life zone doubtless facilitated his march southwards.

In its new home the dipper apparently flourished. Probably the new conditions stimulated development in the direction which seems inherent in nearly all birds, viz., a tendency to assume a more uniformly colored plumage which in time leads to the obliteration of the originally striped or spotted plumage of the young. So the American dippers lost the peculiarly squamated appearance of the Old World cousins and the young became essentially like the adults.[1]

[1] So far as I know, the fledgling plumage of the various South American species is unknown. There are indications, however, that it is not squamated

The geologists tell us that during the lower Tertiary a wide sea rolled across what is now the isthmus of Panama. Until the land rose and joined the two continents the dipper could not pass into South America. However, the connection was made early enough for our purposes and the dipper had probably gained a foothold in the Andes before the advent of the Pliocene.

The specialization begun in North America continued under the southern sky. The large white patch on the underside of the wing is a common birthmark of all the South American species of dippers and proves them all to have descended from a single stock which acquired this character probably shortly after the arrival in South America. Other differentiations in plumage took place aided by more perfect isolation of the various colonies on the boreal islands of an otherwise tropical mountain system than could take place in more northern latitudes. The dipper which reached farthest south (*Cinclus schulzi*) seems to have become most modified, for it has acquired a light rufous throat, a character entirely unique in the genus.

Let us now return to the supposed original home of the dippers in the Chinese mountain. As already stated (p. 424) we have two separate types there, one uniformly fuscous, the other pied, white and dusky. The uniform dark style seems to be the older which preoccupied the mountains of the old land mass to the northeast and east extending as far as Formosa, Japan, and the Stanovoi mountains[1] for an unknown distance. Local influences in connection with more or less imperfect isolation have carved out a number of races such as *C. asiaticus* in the Himalayas, *C. pallasii* in eastern Siberia, Japan, etc., *C. marila* in Formosa, *C. siemsseni* in the province of Fokien, China, *C. souliei* in Tibet, *C. bilkevitchi,* in the Altai Mountains, etc., etc., but with a more or less uniformly colored bird to work upon the variation could not be so very great, and some of these races must be very difficult to distinguish.

The pied style, as exemplified by the common European dipper, probably came into being somewhat later when the western mountain ranges rose up out of the Miocene Sea. According to the rules of zoological nomenclature, which now govern our scientific terminology, the name *Cinclus cinclus* (Linnæus) is that of the " species " and those forms which have been described later are " sub-species," as for instance, *C. cinclus cashmeriensis.* But it is more likely that

[1] By this name is meant the various mountain systems extending in a northeasterly direction from the great bend of the Amur river and forming the watershed between the Arctic and the Pacific Oceans.

it is one of the Asiatic species named much later, which represents the original stock, and that the form to which Linnæus gave the name is the real sub-species. As the land rose to the westward the dippers expanded their range and entered southeastern Europe by way of Asia Minor. One branch apparently continued southwestward and eventually reached the Atlas Mountains in northwestern Africa sending side shoots northward across an ancient land bridge to Sardinia and Corsica. Probably to this branch also belongs the form inhabiting the upper levels of the Pyrenees, as the three forms *C. minor,* from the Atlas, *C. sardus* from the island of Sardinia, and *C. pyrenaicus* are said to be very closely allied. A more northwesterly direction was taken by another branch which eventually reached Central Europe.

Whether the forms which now inhabit Great Britain (*C. gularis*) and the Scandinavian peninsula (*C. cinclus*) belong to the first or to the second branch it is impossible to say at present. It may even be that both branches are represented. The fact is that notwithstanding the great splitting up of *C. cinclus* by European ornithologists lately, there is as yet not sufficient material brought together for a satisfactory solution of the question of the geographical distribution of the dippers in Europe. In a half-hearted, slip-shod way it has been more or less generally accepted that the Scandinavian dipper forms a separable race, by some called *C. cinclus,* by others *C. melanogaster,* but the whole business is so muddled with references to *C. melanogaster* occurring in Ireland, the Pyrenees, Switzerland, Corsica, Caucasus, etc., etc., that all sense has been lost. It is not possible, without a larger material collected systematically for the purpose, to do more than to indicate certain lines of connection in the most timid and tentative way. The fact that the Atlas, Sardinian and Pyrenean as well as some Swiss specimens have been referred to the black-bellied Scandinavian form suggests the possibility of their being related. The records from the British islands do not throw much light upon the subject, for the English ornithologists have given very little attention to the minute relationships of their native birds.[1] A black-bellied dipper has been recorded from Ireland, however, and it is not beyond the possibilities that some of the winter birds of so-called *C. melanogaster* from various points in eastern Great Britain are visitors, not from Norway, as suggested, but from some breeding place in Great Britain itself. The typically

[1] The sarcastic remarks by the reviewer in the "Ibis" (1902, p. 353) of von Tschusi's "feat" in recognizing the British dipper by a subspecific name are quite amusing, but scarcely in the sense intended by him!

black-bellied Scandinavian dipper as found in western Norway might then be suspected of having reached its present home from the west, in which case we would have a most striking parallel to the case of the small race of red deer in western Norway, with apparent relatives in North Africa, Sardinia and Scotland.[1] The suggestion that even the Scandinavian dipper is of double origin (also parallel with the red deer) is borne out to some extent by Professor Robert Collett's record of some specimens from the neighborhood of Kristiania, Norway, which seem to come pretty close to the Central European *C. merula* (Nyt Mag. Naturvid., XXIII, pt. iv, 1877, p. 105). On the other hand, I would call attention to the fact that von Tschusi-Schmidhoffen at the time he diagnosed the British dipper as *Cinclus cinclus britannicus*[2] indicated certain similarities to the typical *C. cinclus*. A great obstacle to a correct appreciation of the relationship of the dippers in Europe is the insufficiency of our knowledge of their distribution in Russia. We do not even approximately know the affinities of the dippers which occur in the Ural Mountains.

It is not even certain that the uniformly dark East Asiatic type is trenchantly distinct from the pied one. Two forms have been described, viz., *C. saturatus* Dresser, from the Baical region, and *C. middendorffi* Sushkin, from the neighboring Sayan Mountains (if these are not identical) which seem to be somewhat intermediate. In that same general region we have a number of other forms, more or less closely allied, yet showing such extremes as *C. leucogaster* with entirely white underside and *C. pallasii*, uniformly dusky above and below, so that one is almost tempted to regard those mountain systems (Suess's "alter Scheitel") as the original radiation center, though the truth may be that the various types in their wanderings have crossed each others' ways just here.

Various authors, for instance Taczanowski, have suggested that some of these intermediate forms are the result of hybridization. While such an assumption might account for certain individual specimens, it does not explain the whole situation. I may here call attention to the fact that nearly all the material, upon which they have based their conclusion, consists of winter specimens which may

[1] See Stejneger, *Amer. Natural.*, XXXV, Feb., 1901, pp. 110–111.

[2] *Ornith. Jahrb.*, XIII, 1902, p. 69. It would seem as if Latham's name *Turdus gularis* (1801) must stand for the British bird, as it is specifically based upon a specimen from Penrith. Moreover, von Tschusi is not the first author to recognize the British bird as distinct and give it a name. That was done in 1890, by Léon Olph-Galliard, Contrib. Faune Ornith. Europe Occid., fasc. XXX, p. 12.

have come together from the most different mountain systems bordering the Irkutsk Amphitheater and Lake Baikal, and that the dippers *nesting* in each of these mountains, such as the Sayan, the Primorski Khrebet, and the Vitim plateau, not to speak of others more remote, differ more or less appreciably from each other.

All these questions are of the utmost importance and interest, but with the present utterly inadequate material at the disposition of the ornithologists, it is scarcely possible to more than lift a corner of the veil. Until the true inter-relations of these birds have been ascertained; until the distribution of the forms thus established has been actually mapped in considerable detail; and until the results thus gained have been verified by correlation with the physiographic features of the country in the field by competent observers; until then we shall have nothing but guesses.

The story of the dippers is not an isolated instance. It is, on the contrary, a typical example of the status of a vast majority of the holarctic animals whose geographical distribution is of the utmost importance for a correct understanding of all the phenomena involved. It will require a wisely planned and carefully conducted biological survey with ample means at its command and a central depository for the vast material which must be gathered by specially trained field agents before the many problems I have only hinted at can be rationally approached. The necessity of attacking the proposition in some such way may be further inferred from another example furnished by the dippers. I need only mention that no less than nine different forms of palearctic dippers have been described during the last two years, the scant material upon which these are mostly founded being distributed among six different museums.

DESCRIPTION OF A NEW SWIFTLET FROM MOUNT KINA BALU, BORNEO

By CHARLES W. RICHMOND

In the small collection of birds presented to the U. S. National Museum by Messrs. Goss and Dodge, and obtained by them during their recent expedition to Mount Kina Balu, north Borneo, is a single example of a small swiftlet that I cannot identify with any described species. It is most nearly related to *Collocalia linchi,* but differs from it in being considerably smaller, and in having rather duller upper parts, with a different shade of gloss (very like the color of the upper surface of *C. troglodytes*). The specimen has every appearance of being adult and full grown, and as there is no individual in our series of *C. linchi* that approaches it, I take the liberty of presenting the following description:

COLLOCALIA DODGEI n. sp.

Type.—Adult, No. 191,575, U. S. N. M., Mount Kina Balu, Borneo, spring of 1904; George H. Goss and H. D. Dodge. Upper parts dusky black, with slight greenish reflections; wings, tail, and upper tail-coverts darker, with a slight bluish gloss; sides of head, chin, throat, breast, and sides of body dark mouse gray, the feathers of the middle of the breast and sides with whitish edges; a partly concealed loral spot white; lower breast and abdomen white, the feathers with dusky bases; under tail-coverts blackish, edged with white, the shorter ones conspicuously so; under wing-coverts blackish, with a faint gloss, the inner feathers narrowly edged with white.

Wing, 90; tail, 33; tarsus, 8 mm.

Collocalia linchi has been recorded from Kina Balu by Dr. Sharpe,[1] who studied the collections made there by Whitehead; but the present bird cannot be matched, either in size or color, by any specimen of *C. linchi* in the National Museum collection.[2] A young example of *C. linchi* recently received from the Philippines (collected on Min-

[1] *Ibis,* 1890, p. 23.

[2] The following localities are represented in the National Museum series of this species: Nicobars, Mergui Archipelago, Pagi Islands (west Sumatra), Linga Island, the Natunas, and Philippines.

danao, by Dr. E. A. Mearns, U. S. A.) is very similar to the adult, differing but slightly from the old birds,[1] and Hartert[2] says the young are "perfectly similar to the adult."

Mr. Goss has sent me the following note about the specimen described above: "The bird was found about the first of May, of this year, on the west side of the mountain. It was killed in flight, and was the only individual of its kind we saw. The natives spoke of some caves away below, where the larger edible-nest-building birds were plentiful, but as they were some four days journey we did not visit them. So far as we knew, there were no caves near by."

Collocalia dodgei is named in honor of Mr. H. D. Dodge, of New York, who was Mr. Goss' companion on his recent expedition.

[1] McGregor (Bull. Philippine Mus., No. 3, 1904, p. 9) writes: "The young are very much like the adults, but the upper parts are strongly glossed with green, while in the adult the wings and tail have a dark steel blue gloss."

[2] Catalogue Birds Brit. Mus., XVI, 1892, p. 509.

REPORT ON LAND AND FRESH WATER SHELLS COLLECTED IN THE BAHAMAS IN 1904, BY MR. OWEN BRYANT AND OTHERS.[1]

By WILLIAM HEALEY DALL

The Bahama islands are particularly interesting to American naturalists, as affording the development of tropical fauna nearest to us; but especially as containing the most valuable evidences of evolution in living animals within a geologically short period ot time. There is no doubt that the entire archipelago has been below the surface of the sea not earlier than the end of the Pliocene, and that the present land and fresh water fauna has developed from ancestors which have reached the islands since that time, from adjacent lands. Among the various kinds of airbreathing animals none are more suitable for a study of evolutionary processes in a very uniform and of late very stable environment, than the Pulmonate gastropods. Slow to migrate; profuse in reproduction; affected by a relatively small number of environmental factors; preserving their variable characters chiefly in their shells, which are easily collected and require the assistance of no taxidermist to preserve from decay; lending themselves readily to fossilization, easily observed and maintained in a living state—they form ideal objects for the study of the questions involved.

Only recently has the effect of isolation on islands shut in by marine barriers been appreciated in its relations to developmental problems, and of all localities accessible to us, where these problems can be studied with ease and without exposure to pestilential conditions none compares with the vast group of rocks and islands known as the Bahamas.

So far, little advantage has been taken of these opportunities, and the work which has been done by Henry Bryant, J. J. Brown, Governor Rawson, Weinland, the U. S. Fish Commission, the expedition

[1] Mr. Bryant desires me to state that this report is the fifth of a series based on collections made by G. M. Allen, T. Barber, and Owen Bryant during part of the summer of 1904. In the present case a representative series of Mr. Bryant's shells is contained in the collection of the National Museum, as a donation from the collector. The Bahama localities in the text are taken from Mr. Bryant's labels, except where otherwise indicated.

of the Baltimore Geographic Society, and now by Mr. Bryant, has been chiefly hurried collecting at as many localities as possible, rather than the patient study of conditions and results, exhaustively applied to any single locality.

However, in any event, much must be left to the future, and every addition to our knowledge is so much gained; and fortunately for science, if not for the easy-going inhabitants of the Bahamas, the spread of agricultural operations and the introduction of domesticated animals progresses so slowly that the natural conditions are not, as in Hawaii, being radically changed before they can be thoroughly studied.

Though somewhat hampered by illness Mr. Bryant collected energetically and in certain localities where time permitted very thoroughly. His journey included opportunities for observation in the vicinity of the south bight of Andros Island especially at Mangrove Cay; at and about Nassau, New Providence; at numerous points on the east and north shores of the Abaco group, and a few points on their south and west shores and at Riding Point, Grand Bahama, opposite; also some of the cays to the westward of Little Abaco.

In a general way each group of islets, or each island inhabited by land shells has its characteristic forms of pulmonate mollusks. Some few forms are widely distributed, but others, especially *Cepolis* and *Cerion*, are for the most part very local, with a few widely distributed species. It is therefore very desirable that the fauna of each island should be thoroughly elucidated. Of the species collected by Mr. Bryant 35 were previously known from the Bahamas, 15 were known to science but not definitely reported from the Bahamas, 4 new species or varieties have been added to the fauna by Mr. Bryant and 14 have been contributed from inedited material in the National Museum, making 18 new forms first described in this report, which covers, in all, 66 species. The total now known from the Bahamas is 174 species and marked varieties.

List of the Species Collected by Mr. Bryant, with Descriptions of Several New Forms.

Oleacina solidula Pfeiffer.

Mangrove Cay, south bight of Andros; Nassau, on the Grantstown road and near Johnson's place; Little Abaco near Marsh Harbor and Nield's, and on the south side at Mathews Point.

The species appears to be common and quite uniform in adult characters.

Pleurodonte provisoria Pfeiffer.

Nassau, near Fort Charlotte, and Mr. Johnson's place; the young burrowing in loose earth under a large banyan tree; at Little Abaco, near Nield's; rather common.

Cepolis varians Menke.

Andros; Nassau; the Abacô group; Elbow Cay, Great Abaco.

Common and very variable, but with many local races. Those at Elbow Cay were all very light colored, etc.

Cepolis troscheli Pfeiffer.

A few specimens were obtained at Nassau, near Fort Charlotte and the Grantstown road.

Cepolis exumana Dall.

Three miles west of Fort Charlotte, Nassau. The species was originally described from Exuma Island.

Cepolis duclosiana Férussac.

Common at Nassau, and quite uniform in its characters.

Cepolis smirna new species. Pl. LIX, figs. 3, 4, 5.

Shell polished, smooth, except for delicate lines of growth, of about four and a-half whorls, the spire moderately elevated, the whorls neatly rounded, the base flattish with a small but deep umbilicus; aperture transversely oval, the lower part of the peristome reflected, white, with a low basal lamina behind it; last whorl at the aperture markedly descending; color of the fresh shell, pale fleshy brown with a rather wide white peripheral band bounded on each side by a dark reddish brown band, the basal one wider than the upper one, which last on the spire runs just above the suture. Major diameter 17.0, minor diameter 14.0, height of shell 9.0 mm.

Habitat. Riding Point, Grand Bahama Island, where many dead (but only one living specimen) were found.

The shell has much the same form as *C. duclosiana,* has a similar basal lamina and umbilicus; but is larger, relatively more elevated, and of a totally different color. It differs from *abacoensis,* which has a similar color pattern, by having a smooth and polished surface.

Cepolis gregoriana Dall.

Riding Point, Grand Bahama; Stranger Cay, crawling on lily stalks, and at numerous localities on Great and Little Abaco.

This form (originally described from Eleuthera) is one of the group of *C. abacoensis,* from which it differs in color and in having no dark brown band below the peripheral pale one, and in being less sharply sculptured. The general coloration of the shell is a somewhat livid purplish brown, lighter or darker; with a narrow pale peripheral band, which is occasionally bounded above by a narrow dark line but perhaps more often merely separates the brown areas of the spire and base. The basal lamina is quite feeble and low, and the sculpture variable.

Cepolis androsi n. sp. Pl. LIX, figs. 2, 7, 8.

Shell small, sharply sculptured with elegantly spaced threads in harmony with the incremental lines, with four moderately convex whorls, a convex base with the lower or pillar lip reflected over and almost completely closing a very narrow umbilicus; the rest of the peristome hardly reflected; basal lamina when fully adult strong and high, parallel with the basal lip; color sometimes uniformly purple brown, or with a narrow peripheral white band under a darker brown line, or with a dark peripheral line with a white one above and below it, or with the brown of the base broken up into four or five spiral bands separated by pale interspaces. Major diameter 13.0, minor diameter 11.0, height 7.5 mm.

Mangrove and Galden Cays in the south bight of Andros Island.

Though a smaller shell this has a more solid basal lamina than *gregoriana* or *abacoensis*, a much smaller and nearly closed umbilicus and less reflected peristome, but it clearly belongs to the same group of species.

Thysanophora vortex Pfeiffer.

Mangrove Cay, Andros; Nassau near Fort Charlotte and in the entrance to the cave at Gladstone's place; and near Johnson's place; and at Mathews Point on the south side of Abaco.

This species has the habit of plastering the outside of its shell with dirt (perhaps its own fæces, as in some species of *Succinea*) which is placed in regularly spaced nodules as well as over the general surface, giving the shell a stellate aspect when viewed from above. Beneath this coating the shell is white or translucent, and when cleaned would hardly be recognized as identical with those retaining their coat of dirt which is doubtless protective.

Thysanophora saxicola Pfeiffer.

Nassau, not uncommon.

This has not previously been reported from the Bahamas though known from Cuba, Jamaica, etc. It is the *Helix mauriniana* of Orbigny.

Thysanophora dioscoricola C. B. Adams.

Nassau, near Fort Charlotte and on the Grantstown road; rare.

This is another addition to the Bahaman fauna, though previously known from Jamaica, Cuba, Florida, etc.

Polygyra microdonta Deshayes.

Common at Nassau and in the Abaco group.

This race of *P. cereolus* Mühlfeldt, appears to be spread completely over the Bahamas having been reported from nearly all the localities where collections have been made. Riding Point, Grand Bahama and Moraine Cay are localities not previously noted.

Microceramus gossei Pfr. var. *providentia* Pilsbry.

Mangrove Cay, south bight of Andros; Nassau; and Little Abaco, near Nield's place.

The allied *M. swiftii* does not seem to turn up from the western Bahamas.

Bulimulus sepulchralis Poey.

Common at Nassau, where it may very likely have been introduced from Cuba. It affects the neighborhood of drains, etc.

Bulimulus bahamensis Pfeiffer.

Mangrove Cay, Andros; and Nassau on the Grantstown road; widely spread through the Bahamas but seemingly not common anywhere.

Urocoptis bahamensis Pfr., var. *providentia* Pilsbry.

Mangrove Cay, Andros; Nassau, near Johnson's place; and on rocks near the entrance to the cave on the Gladstone place.

Cerion ritchiei Maynard.

Mangrove Cay, Andros.

Two very poor specimens which appeared to be this species were taken with hermit crabs.

Cerion glans Küster, var. *coryi*, mut. *agava* Maynard.

From sisal growth near Fort Charlotte, Nassau.

Cerion glans Küster, var. *griseum* Maynard.

Mangrove Cay, Andros Island.

Cerion glans Küster, var. *bimarginatum* Maynard.

Galden and Mangrove Cays near the south bight of Andros, a few defective specimens.

Cerion glans obesum Dall, nov. Pl. LVIII, fig. 15.

This form was obtained from Long Cay, north bight of Andros by the late Prof. John J. Northrop; and from Mangrove Cay, south bight, by Mr. Owen Bryant. While varying somewhat in height it preserves very uniformly its stoutness and irregular sparse ribbing. It has two and a half smooth pale nuclear and nine subsequent whorls of a bluish or brownish white color, sometimes with a purplish undertone, or faintly mottled with irregular blotches of pale brown, the aperture waxen white and deep in the throat warm yellow-brown. The surface is polished, free from spiral striæ, obliquely ribbed with (on the penult whorl 22–28) irregular sharp narrow ribs separated by wider interspaces. The body is subcylindric, the apex short and subacute: the umbilicus minutely perforate, the triangle between it and the reflected peristome rather large. The peristome is rounded and well reflected, the parietal lamina strong, that on the pillar feeble or hardly perceptible.

	Height of Shell.	Aperture.	Max. Diameter.
Long Cay................	29.0	10.0	15 mm.
" "	35.5	11.0	14.5 "
Mangrove Cay............	33.5	11.0	14.0 "

The shell is near *C. glans regulum* Maynard, but is shorter and stouter, more cylindrical, with coarser, less regular, fewer and more widely spaced ribs.

Only a few specimens were obtained by Mr. Bryant, those of Mr. Northrop were better preserved. U. S. Nat. Mus., No. 120,008.

Cerion (*Strophiops*) *watlingense* new species. Pl. LVIII, fig. 7.

Shell small, plump, attenuated before and behind, yellowish white with occasional brown mottlings chiefly between the whitish ribs; peristome yellowish with a brown flush deep in the throat. There are about two brownish smooth nuclear and eight subsequent ribbed whorls; the ribs are nearly vertical, close set with slightly wider regular interspaces, the ribs are of full strength immediately in front of the suture and over the base of the adult; the apex is attenuated in an even curve, the last whorl is more slender than its predecessor. toward the aperture it rises suddenly so that the posterior angle of the aperture is considerably above the middle of the whorl. There are about 28–30 ribs on the penultimate whorl, and no traces of spiral sculpture. The peristome is simple, moderately thickened and reflected, with a thin callus on the body; the parietal fold is strong and short, the axial fold feeble from in front but within well defined; the umbilicus is closed. The size of the eleven specimens collected is unusually uniform.

Height.	Aperture.	Max. Diameter.
25	9	10 mm.
22	7.5	10 "

are the extreme measurements.

No *Cerion* has yet been noted from Watling Island, a mention of *C. glans* in my "Wild Duck" report having been due to an error. This and the following species are therefore the first positively known to come from that island. Though not found by Mr. Bryant, the existence of several unnamed forms was first realized on making an attempt to identify some of his species. As this seems a suitable place for the descriptions they are included. U. S. Nat. Mus., No. 132,970.

Cerion (*Strophiops*) *inconspicuum* new species. Pl. LVIII, figs. 2, 4.

Shell small, white or pale brownish, bluntly spindle-shaped, with about two smooth nuclear and six or seven subsequent whorls; apex arcuately tapering; last whorl moderately attenuated, and, at its termination, ascending a little above the middle of the whorl; umbilicus showing a small open chink; peristome simple, slightly thickened and reflected; the ribs are narrow, small, low and separated by about equal interspaces, slightly oblique and very regular; there is no spiral sculpture. The nuclear shell has two short parietal, and one similar basal denticle; the adult has the single parietal denticle short, feeble, and pustular, the axial lamina almost obsolete.

A variety *lacunorum*, is larger, heavier, and with the parietal and axial laminæ well developed. The measurements are of extremes:

	Height of Shell.	Aperture.	Max. Diameter.
Type	17.0	5.5	6.5–8.0 mm.
Variety	20.0	6.5	8.5 "
"	17.5	5.7	8.5 "

Watling Island, U. S. Fish Commission; the variety on the shores of the lagoon by Dr. J. J. Brown; U. S. Nat. Mus., No. 127,494. The types No. 37,676.

Cerion (*Strophiops*) *canonicum* new species. Pl. LVIII, fig. 13.

Shell stout, solid, whitish or pale brown, sub-cylindric, short, strongly sparsely ribbed and spirally striated. Nucleus prominent, of two and a half whorls, at first smooth then finely transversely striated; subsequent whorls six or seven, with a tendency to constriction a little in front of the suture; the penultimate whorl has about 20 nearly vertical ribs, the interspaces wider and more or less distinctly spirally striated; last whorl rising to the upper third of the whorl at the aperture which is large, with a thin callus on the body and a simple broadly reflected peristome; the umbilicus closed or nearly so; parietal lamina strong, long, extending three quarters of a whorl, axial lamina feeble. Extremes of measurement:

Height of Shell.	Aperture.	Max. Diameter
30.0	11.0	12.0 mm.
27.0	9.0	13.0 "

Gun Cay, Wild Duck expedition. This species was erroneously identified as *C. pannosum* Maynard, which is devoid of spiral sculpture, and comes from south of Cuba. All but one of the specimens obtained were subfossil. U. S. Nat. Mus., No. 127,460.

We now come to a group of three or four species which are apparently related to one another but which have been confounded under the names of valid but different species to which they bear a superficial resemblance.

Cerion (*Strophiops*) *variabile* new species. Pl. LVIII, figs. 1, 6, 14.

Shell varying greatly in size, the typical form handsomely axially irregularly striped with opaque white, dark brown and light yellow brown; with two polished, partly transversely striate nuclear and eight subsequent polished whorls, of which the last is more or less distinctly ribbed, the preceding ones striate transversely or smooth, without spiral sculpture, umbilical chink almost closed. The body of the shell is subcylindric, the last whorl not contracted, sometimes very blunt as if truncate, the apex evenly arcuately domed, the apical portion not swollen. The peristome is simple, rounded, reflected, and the parietal part when fully adult is thick and continuous; the parietal lamina is sharp, and one-third of the whorl long; the axial lamina is well developed only behind the pillar, the latter often seeming destitute of a lamina when examined from in front. The measurements are as follows (U. S. Nat. Mus., No. 120,011):

	Height of Shell.	Aperture.	Max. Diameter.
Type form.......	24–21	7	9.5–10.5 mm.
Var. *saurodon*....	38	13	13 "
Var. *pupilla*......	15.5–20.0	5.0–6.5	5.5–6.5 "

Cerion variabile var. *saurodon* nov. Pl. LVIII, fig. 14.

Shell much larger and heavier than the type form, of about ten whorls, with two nuclear whorls, the apex rather pointed, the last five whorls regularly enlarging, the last the largest, its latter half and base strongly ribbed, the umbilicus perforate, the parietal lamina feeble. U. S. Nat. Mus., No. 120,011*a*.

Cerion variabile var. *pupilla* nov. Pl. LVIII, fig. 1.

Shell small, thin and delicate, subcylindric, smooth, with two nuclear and six and a half subsequent whorls; umbilicus closed; parietal lamina sharply defined, the axial near the base of the pillar, just visible; the peristome is simple, hardly reflected, the parietal part thin; the anterior part of the pillar markedly excavated. This may prove with more abundant material to be a distinct species. U. S. Nat. Mus., No. 120,011*b*.

This species was at first identified as *C. inflatum* Maynard (Acklin Island), though the specimens were collected by the late Professor Northrop at Red Bay on the northwest end of Andros Island. It differs from *inflatum* by its cylindric or conic, not top-heavy form, the last whorl usually ribbed, those preceding irregularly striate or smooth; it has one more whorl, the parietal callus is not only continuous but usually thick when fully adult; the parietal lamina relatively sharp and clean cut, the axial one invisible from in front; the umbilicus open instead of closed. The two forms referred to *variabile* as varieties are similarly colored and from the same locality, but represented by only three specimens. Notwithstanding the enormous difference in size it seems more prudent for the present to regard them as forms of one species.

Cerion (*Strophiops*) *brunneum* new species. Pl. LVIII, fig. 9.

Shell of moderate size, solid, strong, opaque, white, richly striped and flecked axially with dark chestnut brown; form subcylindric with a rather pointed apex and slightly attenuated last whorl. Nuclear whorls two and a half, pale brown, partly transversely striate; subsequent whorls about eight, obsoletely ribbed, the ribbing strongest on the base; umbilicus closed; peristome broad, thick, simple, strongly reflected, yellowish white; the parietal part thin, interrupted except in fully adult specimens. The throat is livid brown, the parietal lamina low, about one third of the last whorl in length, the axial lamina feeble.

Height of Shell.	Aperture.	Max. Diameter.
28.5	10.0	10.5 mm.
26.0	8.0	10.0 "

This appears to belong the *eximium* group, but differs from that species by its nearly obsolete ribbing, base not paler than above, the dark brown throat, the thin and usually incomplete parietal callus, and the parietal lamina not prolonged into the older half of the last whorl.

The specimens were obtained at Governor's Harbor, Eleuthera, by Messrs. Bean and Riley in 1903. U. S. Nat. Mus., No. 173,266.

Cerion (*Strophiops*) *plegmatum* new species. Pl. LVIII, fig. 5.

Shell of moderate size, light and thin, subcylindric, with two and a half polished, pale, latterly microscopically reticulate whorls, followed by seven smooth or feebly striated whorls axially striped or clouded with dark or light brown and opaque white. Umbilicus closed, base attenuated, apex rather pointed; peristome thin, simple, yellowish white, broadly reflected, in the adult continuous over the body; parietal laminæ short, compressed, axial lamina low, inconspicuous; the base of the last whorl sometimes strongly axially striated.

Height of Shell.	Aperture.	Max. Diameter.
18.5	6.0	8.0 mm.
22.0	7.0	9.0 "
26.0	8.0	8.0 "

Numerous specimens were collected by Dr. J. J. Brown of Sheboygan, Mich., at Exuma Island. U. S. Nat. Mus., No. 37,674.

This species is much like *brunneum*, from which it differs by its smaller, more delicate, and thinner shell, narrower and much shorter parietal lamina, its thinner and less reflected peristome, and its last whorl rising much less at its termination. From *C. inflatum* of Acklin Island, it differs especially by its striate last whorl, and more evenly fusiform shell not swollen toward the apex. This species was identified as *inflatum* by Mr. Maynard, as stated in Dr. Pilsbry's monograph of the genus, but a careful study of it shows that it cannot be so united.

Cerion (*Strophiops*) *Northropi* new species. Pl. LVIII, fig. 11.

Shell of moderate size, thin, delicate, cylindric, with two pale polished nuclear and nine subsequent whorls; white, with sparse narrow irregular oblique brownish streaks; body cylindric, the apex forming a short dome, last whorl hardly attenuated, with a closed umbilicus, simple, well reflected white peristome and feeble parietal callus; parietal lamina small, short (about 4 mm.), axial lamina sharp but hidden; sculpture of (on the penultimate whorl) about 66 very fine, quite oblique, regular even ribs, with narrower interspaces, uniform over the whole shell.

Height of Shell.	Aperture.	Max. Diameter.
27.0	9.0	10.0 mm.
30.0	10.5	10.0 "

"Bahamas," Greegor (probably one of the westernmost islets near Gun Cay). U. S. Nat. Mus., No. 124,135.

This resembles externally *C. Dalli* Maynard, which has a long parietal lamina, and less closely *C. milleri* Pfr. of the Exuma group. There is no other species at all near to it figured by Dr. Pilsbry in the Manual.

That which most suggests it is perhaps a depauperate variety of *C. agrestinum* Maynard, which is easily distinguished by its more solid character, ovate form, larger aperture and more conspicuous peristome. The specimens were obtained from some one of the small cays on the eastern side of Florida strait, but the donor, Mr. I. Greegor, was unable to find out which islet.

Cerion eximium Maynard.

One specimen found at Nassau.

Cerion oweni new species. Pl. LVIII, figs. 3, 8, 10, 12.

Typical form south side of Little Abaco, opposite Marsh Harbor, and on the opposite shore of Grand Bahama at Riding Point; variety *reticulatum* at the Sugar Loaves, rocks northwest of Elbow Cay, off Great Abaco; variety *incisum* (nearly all dead or subfossil). Stranger Cay, northwest of Little Abaco, and one specimen, apparently the same, at Sweeting's village, Little Harbor, Great Abaco; var. *vermiculum* at Mathews Point, south side of Great Abaco. This member of one of the most difficult groups of *Cerion* has been submitted to Dr. Pilsbry, who regards it as new and forming a parallel series to *C. agrestinum* Maynard, from New Providence. As he has recently monographed the group I have adopted his opinion. The species is named in honor of Mr. Owen Bryant, the collector.

Typical form. Pl. LVIII, fig. 12.—Shell large, slender, ashy white, or white marbled and longitudinally streaked and clouded with nut brown of varied intensity; the apical 2½ whorls subtranslucent, the remaining ten opaque, smooth and somewhat polished, or more or less sculptured by fine oblique wrinkles with subequal interspaces about three to one millimeter on the line of the suture; apex beehive-shaped; remainder of the shell subcylindric, the last whorl rising a little near the aperture, the peristome thickened, somewhat reflected, rounded, simple, waxen white; throat brownish, with a short low parietal and feeble axial lamina or ridge of callus; umbilicus with a deep narrow chink; the sutures are not impressed; the immature shells are trochiform, with a narrow axial perforation, a small sharp lamina on the pillar, usually a short feeble tooth on the roof of the aperture and very rarely a faint trace of a callosity on the basal wall also, but I have noticed this only once or twice; measurements of the mutations of this species show the following as divergencies (U. S. Nat. Mus., No. 179,442):

Surface.	Whorls.	Height.	Max. Diam.	Type Form.
Smooth	12.5	37.0 mm.	12 mm.	"
Smooth	10.5	28.5	11.25	"
Feebly striate	12.5	37.0	12.5	"
Sharply striate	12.0	27.0	10.0	"
Sharply striate	12.0	26.5	8.0	"
Feebly striate	9.5	21.0	8.0	"
Subreticulate	11.0	26.0	10.0	variety a.
Subreticulate	9.5	21.5	10.0	" "
Very sharply striate	12.0	28.0	10.0	variety b.
Very sharply striate	10.0	25.0	12.0	" "
Very sharply striate	11.0	22.5	11.0	" "
Very feebly striate	10.0	19.0	7.5	variety c.
Feebly striate	10.0	19.5	7.0	" "

Variety a (*reticulatum*). Pl. LVIII, fig. 8.—Shell smaller, colors tending to livid or purple below ashy white, which is arranged more or less in narrow spiral lines which cut the white wrinkles at nearly a right angle giving a very marked reticulate effect, the striation notably sharper than in the type form. U. S. Nat. Mus., No. 179,443.

Variety b (*incisum*). Pl. LVIII, fig. 10.—Shells stouter, with still sharper sculpture, the form top-heavy, with the maximum diameter nearer the apex than to the base, a less marked umbilicus; the young with a larger axial perforation and on both the upper and lower walls of the aperture a pair of strong short low laminæ beside one on the pillar, making five in all, in the aperture of a shell with six whorls. U. S. Nat. Mus., No. 179,440.

Variety c (*vermiculum*). Pl. LVIII, fig. 3.—Shells small, nearly smooth, slender, subfusiform, with the color in large subaxial marmorations or nebulæ. U. S. Nat. Mus., No. 179,442.

The range of variation in size, sculpture, and color, as above noted, is very large yet the various forms have nevertheless a general resemblance which points to their common origin. Large numbers of the typical form were obtained.

Dr. Pilsbry remarks of them: " a species not hitherto known, very closely related to *agrestinum* of New Providence, but with a general tendency to be larger, longer, more solid and varying to smooth, which *agrestinum* is not known to do. The umbilical slit is also ordinarily longer in your shells and the parietal lamella smaller. The suture above is also more seam-like. These forms are also related of course to *marmoratum, martensi,* and various other forms all more remote geographically than *agrestinum*. *C. fordii* is a stouter more coarsely sculptured species."

Pupoides marginatus Say, var. *modicus* Gould.

Nassau, near Fort Charlotte, and Mangrove Cay, Andros; common.

The form of *P. marginatus* found on the islands and on the continent from Chesapeake Bay southward, *near the sea,* is the form named *Pupa modica* by Gould. Inland however, even in Florida it assumes its larger and more solid typical form. In a large series a perfect gradation between the two may be established.

Bifidaria servilis Gould.

Mangrove Cay, Andros and commonly at Nassau near Fort Charlotte and the Grantstown road.

Subulina octona Bruguière.

Nassau, at various localities, common.

Opeas octonoides C. B. Adams.
Mangrove Cay, Andros; and Nassau.

Opeas subula Pfeiffer.
Nassau, in loose earth; and Abaco, near Marsh Harbor.

Opeas micra C. B. Adams.
Nassau.

Opeas paupercula C. B. Adams.
Mangrove Cay, Andros, and at Nassau in the grounds of the Colonial Hotel and on the Grantstown road.

This species, described from Jamaica has not hitherto been known from the Bahamas.

Lamellaxis pallidus C. B. Adams.
Nassau, in the grounds of the Colonial Hotel and on the Grantstown road, in loose earth.

This form was described as a *Bulimus* by Adams and has been referred to a group named *Lamellaxis* by Strebel and identified by von Martens with *Leptinaria*. Originally named from Jamaica it is now first reported from the Bahamas.

Orthalicus undatus Bruguière.
Nassau, with hermit crabs; Mangrove Cay, Andros, one specimen with crabs. None found living.

Melaniella gracillima Pfeiffer.
Mangrove Cay, Andros; under leaves and bushes on a side hill near Fort Charlotte, Nassau, N. P.

Caecilioides acicula Müller.
A single specimen was found with *Opeas* in loose earth, on the Grantstown road, Nassau. This species has been reported from Florida and Bermuda but not hitherto from the Bahamas.

Zonitoides minusculus Binney.
A single specimen was obtained in the grounds of the Colonial Hotel, Nassau.

The species is new to the Bahamas though previously known from Florida, Bermuda and Jamaica.

Succinea ochracina Gundlach?
Young specimens, distinguished from the following species by the more acute spire and deep orange color, were found near Johnson's place and Lake Cunningham, also in the grounds of the Hotel Victoria in Nassau. The typical locality is in Cuba.

Succinea barbadensis Guilding.
Very common at Mangrove Cay, Andros, and near Fort Charlotte, Nassau.

The young cover the shell to a greater or less extent with pellets of their own fæces.

Veronicella schivelyæ var. *bahamensis* nov. Pl. LIX, fig. 1.

Near Johnson's place, Nassau, and on Little Abaco, at Nield's place.

This large *Veronicella,* while not agreeing in all particulars with Dr. Pilsbry's account of the Bermuda species, is evidently closely allied to it.

The young are translucent white with two dark lines enclosing a broad, elongated area on the back which is pale and outside of which the sides of the mantle are finely gray-dotted. The foot and whole underside are pale waxen but the oculiferous tentacles are conspicuous by their dark slate color in contrast to the rest of the animal.

The adult is of a purplish livid color in general, though sometimes albinistic; the back shows a narrow light median dorsal line, and two broad somewhat hazy dark bands corresponding to the dark lines of the young, but the pale dorsal area is more or less clouded with grayish purple. The genital pore is not so close to the foot as in Dr. Pilsbry's specimens from Bermuda, and the lighter dorsal area is broader in Bahama specimens. The animal itself, as far as one can determine from alcoholic specimens, is rather broader and stouter than the Bermuda variety. It measures, in two specimens; total length 54 and 63 mm., breadth 25.5 and 26.5; the sole is 9 and 10 broad, and 54.5 and 62.5 long; the genital pore is distant from the anterior edge of the mantle 31 and 33; from the posterior edge of the mantle 23 and 27; from the sole 3 and 2.5, from the lateral edge of the mantle 5 and 6 mm.

Numerous specimens were obtained at Nassau, and it is probably widespread, but rarely noticed by travelers because it is nocturnal in its habits. It seems to have been the only slug noted during the expedition.

Segmentina (*Planorbula*) *dentata* Gould.

Mangrove Cay, Andros.

Mr. Bryant writes "I found all the *Planorbis* in dried up pond holes in the lime rock near what is called the "shore road," really a path, about a mile from the village of Mangrove Cay. When I saw them there had been little rain and there was nothing but mud with some grass and reeds growing in it, and one or two crab holes where there was still some water and very soft mud. Near the top of the holes and over most of the bottom were scattered large numbers of dead *Planorbis* and a few *Physa.* The first hole I examined was about ten or fifteen feet across and about four feet deep. I found in it only one or two Physas but there were a great many *Planorbis*. I was much puzzled as to whence they came, and made a careful search to see if I could find any live ones. I examined the mud and looked in the very bottom where the mud was still soft but could unearth none. Then I looked in the crab holes, feeling round the sides and taking up handfulls of mud from the sides and bottom and straining it through my net. I thought there must be considerable numbers of live ones somewhere or there would not be so many freshly dead ones, but could find no trace of any. Later I discovered a pond where the natives shoot wild fowl in winter, and called by them the "duck pond." Hereabouts the land is nowhere more than eight or ten feet above high water mark, and probably the water in this pond was in subterranean communication with the sea, not more than a quarter of a mile away. The pond was one hundred yards or more from where I found the *Planorbis*. It was a natural pond, very shallow, but with a soft muddy bottom over the lime rock, and all about it bushes and trees were thick. The trees extended into the water, growing in it to a depth of two feet. In the pond were some fresh water algæ and other plants. I thought I had found where my *Planorbis* came from, but on most careful search I could not find one alive or dead, but did find a few *Physa*, some of which were alive. The pond was the only one I heard of, remote from the village, difficult of access and there was no water about where anything in the shape of aquatic plants had been imported. Therefore I think there is no possibility of the *Physa* being imported. Probably the water was salt or at least brackish near the bottom. There were a number of the lime sinks which had been cleaned out to form "wells," and one or two deep sinks which had water in them fresh enough to drink. In one of these, two miles from the duck pond and back of the village I found one *Physa*."

The explanation, as far as the planorbes are concerned, is that they form epiphragms when the waters of the pool dry up and remain in this condition alive but quiescent until the rains fill up the pools again. Many of the specimens of *P. redfieldi* showed the epiphragm, usually double, very clearly through the translucent shell. I believe this habit has not before been recorded of *Planorbis*.

I agree entirely with Mr. Bryant's conclusion that these fresh water species are indigenous and native to the islands. There are many ways by which such pools may be stocked. The greater profusion of specimens in the pools and their scarcity in the permanent pond may well be due to the presence in the pond of fish and wild fowl, which feed eagerly on such fresh water snails, but could not live in pools periodically dry. The majority of the numerous *Planorbis* obtained by Mr. Bryant was composed of the *P. redfieldi*, the *Segmentina* is comparatively rare. Years ago I received from Dr. Brown a single specimen of the latter, from the drift on the shores of the lagoon at Watling Island.

Planorbis redfieldi C. B. Adams.

Mangrove Cay, Andros, common.

This species was originally described from Jamaica, and is an addition to the fauna of the Bahamas; the manner of its occurrence has been described under the last species.

Physa acuta Draparnaud.

Mangrove Cay, Andros; not abundant. Watling Island (J. J. Brown).

This species was identified by D'Orbigny in 1842, from Cuba, Jamaica, Guadeloupe and Martinique, as well as South Europe and the Canary Islands. Later it was found in large numbers in one of the hothouses at Kew Gardens by Jeffreys, introduced with aquatic plants from the West Indies. Dr. Brown Goode collected specimens from water tanks at Bermuda, which were identified by Dr. Pilsbry. I received a single specimen from Watling Island. Now Mr. Bryant adds it to the fauna of the Bahamas. I formerly supposed this species to be an introduction from Europe, but am now quite confident that it is indigenous to the Antillean region. I have carefully compared European and Antillean specimens and find the differences slight and inconstant, though one would not expect a fresh water shell to have such a geographical distribution. An anatomical examination will be required to remove all lingering doubts as to their identity. Mr. Bryant's specimens are all immature.

Tralia pusilla Gmelin.

Sweetings village, Abaco. Also Florida, Bermuda, etc.

Melampus (*Detracia*) *bulloides* Montagu.

Andros Island at Mangrove Cay.

A single young specimen was obtained. The species had previously been reported from Nassau. Also at Riding Point, Grand Bahama.

Pedipes mirabilis Muhlfeldt, var. *tridens* Pfr.

Andros, at Daulin Bay, Sweeting's village, Abaco.

This species is quite variable in the coarseness of its spiral sculpture. Young specimens with fine sculpture and in which the median callus inside the outer lip has not yet formed, were named *tridens* by Pfeiffer, and when the callus appears are *quadridens* C. B. Adams. The very young are *ovalis* C. B. Adams, and the old coarsely sculptured and strongly dentate specimens are typical *mirabilis*. The form varies from ovate-elevated to naticoid. I think this is the first time this species has been definitely reported from the Bahamas.

Blauneria pellucida Pfeiffer.

A single specimen was obtained at Mangrove Cay.

This minute shell has been reported from Florida, the West Indies and Bermuda, but not previously from the Bahamas. It is either generally rare or from its small size and subterranean habits has been overlooked by collectors.

Siphonaria alternata Say.

Mangrove Cay, Andros; Little Abaco.

This had previously been obtained at Gun Cay, by the U. S. Fish Commission.

Chondropoma revinctum Poey.

On the Grantstown road, Nassau, N. P., U. S. Fish Commission and Owen Bryant.

This species, which has been kindly identified for me by Dr. Pilsbry from specimens in the Academy of Natural Sciences, was originally described from the south side of Cuba near Manzanillo. There are several nearly allied species in Haiti. Having been found at a wide interval by two expeditions it seems that it must have become well established, though recently introduced, since it is so handsome and conspicuous a species that, existing now in the best explored region of the group, it could hardly, if present, have been overlooked by all previous collectors.

It is now first recorded from the Bahamas.

Rhytidopoma euploca new species. Pl. LIX, fig. 6.

Inagua, Bland. Three specimens.

I describe this species here, because it is an addition to the Bahaman fauna discovered under a wrong name in the Museum collection while endeavoring to identify Mr. Owen Bryant's material. It was received by Stearns from Bland and subsequently was acquired by the National Museum.

Shell small, with four moderately convex whorls after decollation; somewhat irregularly but strongly crenulate at the suture; color honey yellow, more or less faintly articulated, striped, dotted or clouded with pale reddish brown; sculpture of fine low spiral threads (about 10 on the penultimate whorl) with narrower and more translucent interspaces, crossed by much finer, regular, sharply defined axial threadlets, most evident in the interspaces and giving a textile effect to the surface; the revolving threads a little stronger on the base; umbilicus small, perforate, not covered by the narrow peristome; termination of the last whorl not free from the body; aperture, short, ovate, yellowish, showing the brown spirals internally; peristome narrow, slightly reflected, little thickened, but somewhat angular behind; operculum thin, the calcareous layer thin, its disposition similar to that of *Ctenopoma rugulosum* Pfr., the type of the genus *Rhytidopoma* Sykes. Height of shell 8.0; maximum diameter of shell 4.0; of aperture 2.6 mm.

Opisthosiphon bahamensis Shuttleworth.

Typical locality Nassau; collected by Mr. Bryant in various localities at and near Nassau; Great Abaco, on the Sugar Loaves rocks; Little Abaco near Nield's and Marsh Harbor, and Mathews Point on the south side of Abaco.

This is the most abundant species of the family in the Bahamas, and, considering its wide distribution, is very uniform in character: differing chiefly in color, the Nassau variety being frequently of a livid purpuraceous tint while the specimens from the outer and eastern islands are more disposed to assume a yellowish color with fairly distinct dottings or streaks of brown. The differences of size, probably correlated with the food supply, are not very marked. This, with the allied *O. rawsoni* Pfr., belongs to a new genus[1] characterized by a little tube which is formed behind the posterior angle of the peristome and turned with its aperture close to the surface of the preceding whorl; so that, when the animal protects itself by hermetically closing the aperture of the shell with the operculum, air can still be admitted through this little tube to the interior, though the orifice is not large enough to give access to any enemy of the species. This tube at a later stage is closed up permanently.

Specimens of this species in the National Museum were named by Bland *C. biforme* Pfeiffer, but I am informed by Mr. E. A. Smith of the British Museum that the true *biforme* is a species of *Chondropoma.*

Helicina fasciata Lamarck.

Mangrove Cay, Andros, in dead sisal; Riding Point, Grand Bahama; Cuba.

This species appears to be rather rare, as Mr. Bryant obtained only a few immature and one dead adult specimen. It had not previously

[1] Cf. Proc. Malac. Soc. London, VI, p. 209, 1905.

been recorded from the Bahamas in print, though there are Bahama specimens in the National Museum collection, obtained many years ago by the late Dr. Henry Bryant of Boston. A curious fact was developed while making the comparisons with other specimens of *Helicina*. Nearly fifty years ago a single specimen of *Helicina* was sent to the Smithsonian from Key Biscayne, Florida, and identified as *H. subglobulosa* Poey, a Cuban form. There are specimens of *H. subglobulosa* from Florida in the collection, of more recent date, but the original specimen is undoubtedly an example of *H. fasciata*. The figure in the Land and fresh water Shells of North America (f. 220) part III, p. 111, is very poor.

Helicina bryanti Pfeiffer.

Inagua, Dr. H. Bryant; Nassau and Mangrove Cay, Andros, Owen Bryant.

This seems to be common and widespread. Large bleached specimens from Turk's Island are *H. candida* Pfeiffer, and *H. calida* Weinland, from Crooked Island can hardly be distinguished.

Schazicheila bahamensis Pfeiffer.

One specimen was found on the Grantstown road near Nassau, and another at Mathews Point on the south side of Abaco, by Mr. Bryant.

The fresh shell is of a brownish red color, the tint changing after death and exposure to a pale yellow of very different aspect.

Truncatella pulchella Pfeiffer.

Mangrove Cay, Andros, Hopetown and Sweeting's village, Abaco.

Truncatella bilabiata Pfeiffer.

Nassau, N. P., also in beach drift at Long Rock, Abaco.

Truncatella clathrus Lowe.

Riding Point, Grand Bahama, Sweeting's village, Abaco.

This has not previously been recorded from the Bahamas though registered from Bermuda, Florida, Porto Rico, St. Thomas, etc.

Assiminea concolor C. B. Adams.

Jamaica (Adams as *Phasianella concolor*); Lagoon of Watling's Island; Bermuda (C. B. Adams and C. A. Davis); under stones at high water. Key West (Hemphill); Point Pinallis near Tampa, Florida (E. Jewett and R. E. C. Stearns); Mangrove Cay, south bight of Andros Island (Owen Bryant).

This differs from *A. affinis* Orbigny, in its more rotund and polished whorls, and somewhat larger size. *A. concinna* C. B. Adams (as *Cingula*) has an impressed line in front of the suture. I have not seen specimens, but the species was described from Jamaica. The species from Cedar Keys which I listed in Proc. U. S. Nat. Mus., VI, p. 335, as *A. auberiana* Orbigny, is not Orbigny's species. The latter is probably a Rissoid, and the Cedar Keys species is likely to prove identical with *A. turricula* H. C. Lea (as *Cingula*) described from South Carolina. The possession of cotypes of C. B. Adams *Phasianella concolor,* received from the author, enables me to feel certain about the identification of Mr. Bryant's shells.

Cyrena colorata Prime.

South side of Abaco, and at Riding Point, Grand Bahama.

This is not exactly a fresh water shell, but occurs in the mud of brackish marshes.

Cyrenoida americana Morelet.

South side of Abaco; also Cuba and Porto Rico.

This has a *situs* similar to that of the last species.

EXPLANATION OF PLATES

All the figures are natural size.

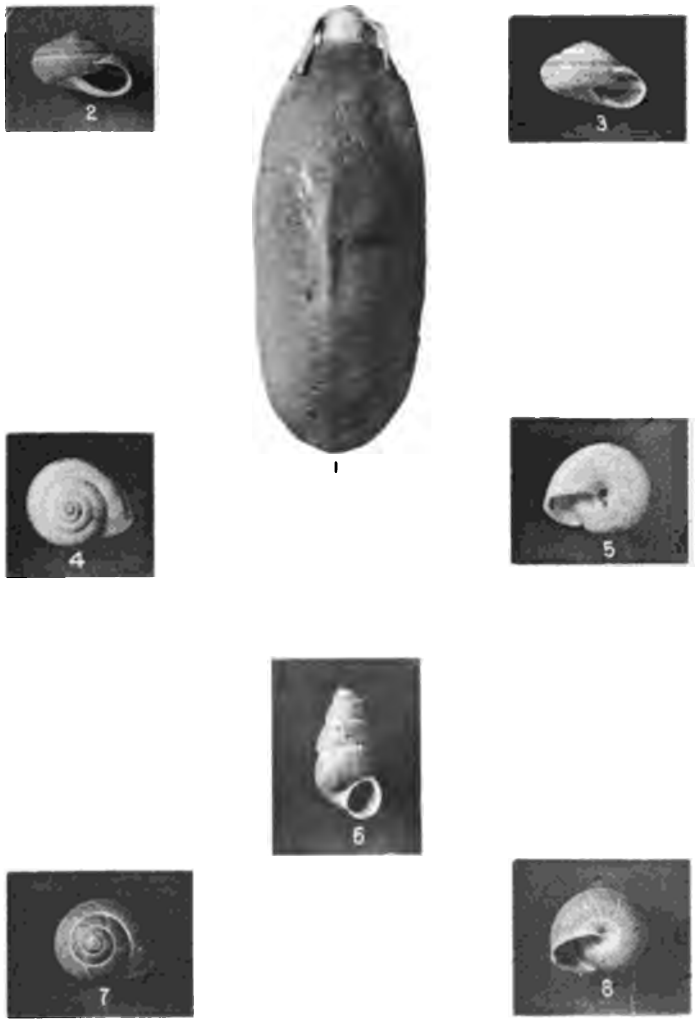
PLATE LVIII

FIG. 1. *Cerion variabile* Dall, var. *pupilla* Dall........................p. 440
2. *Cerion inconspicum* Dall....................................p. 439
3. *Cerion oweni* Dall, var. *vermiculum* Dall....................p. 444
4. *Cerion inconspicuum* var. *lacunorum* Dall....................p. 439
5. *Cerion plegmatum* Dall.....................................p. 441
6. *Cerion variabile* Dall, typical form..........................p. 440
7. *Cerion watlingense* Dall....................................p. 438
8. *Cerion oweni* var. *reticulatum* Dall. The bluish spiral color-markings do not photograph clearly........................p. 44
9. *Cerion brunneum* Dall......................................p. 441
10. *Cerion oweni* var. *incisum* Dall.............................p. 444
11. *Cerion northropi* Dall......................................p. 442
12. *Cerion oweni* Dall, typical form.............................p. 443
13. *Cerion canonicum* Dall.....................................p. 439
14. *Cerion variabile* var. *saurodon* Dall.........................p. 440
15. *Cerion glans* Küster, var. *obesum* Dall......................p. 437

PLATE LIX

FIG. 1. *Veronicella schivelyæ* Pilsbry, var. *bahamensis* Dall. The color-markings and the median pale line do not show in this photograph from an alcoholic specimen....................p. 446
2, 7, 8. *Cepolis androsi* Dall.....................................p. 436
3, 4, 5. *Cepolis smirna* Dall. The specimen figured is smaller than the type and slightly bleached...............................p. 435
6. *Rhytidopoma euploca* Dall.....................................p. 449

BAHAMA SHELLS



BAHAMA SHELLS

GENERAL VIEW OF VICTORIA GLACIER AND TRIBUTARY

GLACIAL STUDIES IN THE CANADIAN ROCKIES AND SELKIRKS

(Smithsonian Expedition, Season of 1904.) Preliminary Report

By WILLIAM HITTELL SHERZER, Ph.D.

The glaciers selected for special investigation and report are located in Alberta and British Columbia, along the line of the Canadian Pacific Railway; being those which are at the present time most readily accessible to the tourist, or student of glacial phenomena.[1] They represent the outflow from the great snow-ice masses which accumulate, season after season, upon the higher slopes of the Rockies and Selkirks. These five glaciers, upon which a preliminary report only is here offered, lie in north latitude 51° 12′ to 51° 38′ and west longitude 116° 12′ to 117° 30′, about 100 miles north of the international boundary. Owing to the interposition of three minor ranges between the Canadian Rockies and the warm waters of the Pacific, all of them having a north to south trend, the moisture-laden westerly winds yield an abundant precipitation upon the western slopes of these ranges, leaving relatively little for the main range itself. This loss, however, is more than compensated by extra altitude and by the greater size of the catchment basins between the ranges of that great stone heap known as the Rocky Mountains. The records of the Canadian Meteorological Service, available since 1890, give for Banff, lying just east of the continental divide, an average annual rainfall of 12.89 inches and of snow 81.9 inches. When reduced, this represents a total precipitation of 21.08 inches, or in snowfall 17.57 feet. At Glacier House, in the Selkirks, near which are located the two westernmost glaciers studied, the total average precipitation is 2⅔ times as great, giving 56.63 inches as rain, or 47.19 feet when all reduced to snow. Practically this entire amount over the collecting areas is available for the making of glaciers, since when it rains in the valley it very commonly snows over the nevé region and when rain does fall here it is absorbed and soon converted into ice.

[1] A brief report of this expedition appeared in the Quarterly Issue of Smithsonian Miscellaneous Collections, Vol. 47, p. 298.

I. VICTORIA GLACIER.

1. *Nourishment.*—Because of its activity and varied phenomena this glacier, lying between Lake Louise and Mt. Victoria, is of especial geological interest and some six weeks' time was devoted to its study. Starting from Abbott's Pass, upon the continental divide, with an elevation of 9,400 feet above tide, it flows to the north and then northeast for a distance of three miles and before wasting away reaches an altitude of some 6,000 feet. About one mile back from its nose it receives a tributary, the Lefroy glacier, from the southeast which is fed by the snow that accumulates upon either side of the Mitre and the eastern shoulder of Lefroy. Plate LX[1] shows the

FIG. 64.—The making of avalanche cones, Victoria glacier. Photographed by De Forrest Ross.

relation of this tributary to the main stream. The nearness of the medial moraine to the right lateral (the glacier's right) shows that the Lefroy is contributing relatively little ice but most of the rock debris with which the lower part of the Victoria is completely mantled. The extensive snowfield upon the eastern slope of Mt. Victoria, receiving an annual fall of 20 to 25 feet, is avalanched into the narrow valley lying between Mt. Lefroy and Mt. Victoria and this is the chief source of supply for the Victoria, it being, to a large

[1] Reproduced here through the courtesy of the Detroit Photographic Co.

extent, a reconstructed glacier. During the hot days of the summer these avalanches are of frequent occurrence, crashing into the valley hundreds of feet below with the sound of thunder and the blast of a tornado (fig. 64). In the narrower portion of the valley, known as the " Death Trap," they may shoot completely across and thus contribute rock fragments to all parts of the glacier.

Aberdeen. Lefroy.

Fig. 65.—Debris covered nose of Victoria glacier.

2. *Frontal Changes.*—The Victoria presents an oblique front of nearly one half mile, the general direction of which so nearly corresponds with the main axis of the glacier that there is much doubt as to whether we have the actual front or the side (pl. LXI, *a*). An inspection of the ancient moraines in the valley shows that the front has been gradually swinging around into this position, the ice melting more rapidly upon the western side where less protected by debris. Here for a distance of about 1,600 ft. there is a distinctly stratified ice front, inclined from 35° to 50° and reaching a height of 75 ft. to 100 ft. In midsummer of 1898, there fell from the face of the ice an exceptionally large red quartzite boulder, which was photographed by Prof. C. E. Fay while still in position and a week later when it had fallen. One year later the distance of this boulder from the ice front was found by George and William Vaux to be 20 ft.; perhaps one-half of this distance being due to recession. In

the five years which have elapsed since, the base of the ice front has receded 55 ft., or an average of 11 ft. a year.

Some distance down and upon the eastern side of the valley is located the real nose of the glacier (fig. 65), the ice being completely concealed by the debris from the right lateral and medial moraines. Owing to the protection from the sun afforded by this veneering of rock, combined with the sluggish condition of the ice along the side, this nose is stagnant, or practically so, at the present time. The last episode was one of advance, indicated by the manner and extent to which the glacier has pushed into the forest of spruce and fir (pl. LX). The fallen trunks and cut stumps, however, now seen here were produced by a small snow slide, some decades ago, which came down from between Castle Crags and Mt. Aberdeen, encircling the nose when the ice stood somewhat farther back than at present. Accurate measurements were made with a steel tape between blocks of an ancient moraine and others firmly planted in the face of the frontal slope, here having an angle of about 38°. These measurements showed that the latter blocks had settled backward an inch in the 66 days from July 9 to September 13, and the inference is that the ice beneath is slowly wasting faster than it is replenished from behind. Confirmatory evidence of such wastage is furnished by a small stream of clear, ice-cold water which issues from amongst the rocks just west of the nose. So long as present conditions persist, the recession will continue here with extreme slowness, but it is obvious that a very slight additional impulse from behind would inaugurate an advance.

3. *Forward Movement.*—At the lower end of the sharply crested left lateral moraine shown in plate LX, a line of eighteen steel plates was set, approximately 100 ft. apart and back 3,600 ft. from the nose. The down-valley movement of these plates was accurately determined with a transit for a period of ten cool days (July 9 to 19) and then for a similar period of relatively warm ones (July 19 to 29).[1] As was to be expected the movement was found to increase from the sides, where it was practically nothing, towards the center and to have been appreciably less for the cool period. The maximum forward movement occurred in the broad, general depression in which is seen the surface drainage channel, two-thirds of the way across, and averaged for the cool period 2 inches daily, for the warm

[1] For the cool period the average daily minimum near the nose was 38.76° F., average maximum 60.36° F., total range 30.9° to 74.0° F., precipitation .671 inches. For the warm period the average minimum was 39.59°, average maximum 67.96°, total range 34.8° to 75° F., precipitation .84 inches.

period 3.6 inches daily and for the entire period (July 9 to 29) 2.75 inches, which latter figure may be taken as the average daily summer motion for this part of the glacier. If we assume a minimum winter motion of one-fourth this amount we shall get as the probable yearly motion here about 52 ft. Further up where the inclination is greater there is reason for thinking that the rate of movement is much greater.

4. *Ablation.*—Accurate elevations upon the steel plates used in the above work were taken with a spirit level for the purpose of constructing a cross-section of the glacier here and also for the purpose of determining the amount of surface melting for a definite period. It was thus found that the surface of the ice was being lowered most rapidly in the neighborhood of the plate which showed the maximum forward movement and from July 9 to August 4 amounted to 3.794 ft., or a daily average of 1.75 inches. This effect is produced mainly by the sun, which in the rarified atmosphere of these high altitudes, strikes with surprising force, transforming the water from its solid to its liquid condition, without changing its temperature. Other agencies are the atmosphere, generally above the freezing temperature during the summer months, and the rain, 1.506 inches of which fell during the above period of observation. Subglacial erosion and melting may assist also in lowering the surface of the glacier at any given point, as may also the longitudinal stretching, or lateral spreading of the ice, but for limited periods these effects may be disregarded. From the above data it would appear that the surface melting over the lower third of the Victoria for July and August should be about 9 ft. Independent observations upon the lower Lefroy showed that the ice surrounding certain morainic heaps had been lowered during the season by about this same amount. No glacial tables of this height are to be found, owing to the undercutting effect of the sun's rays and their consequent destruction of their pedestals. The broad medial depression lying to the west of the medial moraine (pl. LX) has been produced by the relatively greater melting here and this is permitted by the thinner covering of rock debris, the ice of this portion of the glacier coming from the Lefroy side of the valley. This depression continues down the valley for 2,200 feet, where it thins out, apparently by surface melting. If the estimated forward movement is approximately correct and continuous for this region it would require about 42 years for the ice to pass from the line of plates to the lower edge, during which time, at the rate of 9 ft. a year, about 378 ft. of ice could be melted, and this should represent the approximate thickness of the

ice beneath the line of plates. The work with the level gave a difference of 393 ft. between the base of this ice at the margin and the plate which gave the maximum surface melting and forward movement. This would leave but 15 ft. for the rise in the valley floor in the 2,200 ft., an amount which is very probably too small and it is likely that the surface melting becomes less toward the lower margin owing to the concentration of the debris.

5. *Shearing.*—The steeply inclined ice front at the western side of the valley shows a succession of ice strata, more or less well defined, which dip back into the glacier at rather a steep angle. At the mouth of an abandoned drainage tunnel, seen in pl. LXI, *a*, these strata have a dip of 26°, which is somewhat below the actual dip when measured at right angles to the strike. There is some sand, a little fine gravel and, occasionally, a cobble-stone between these strata but the amount of foreign material is small and inconspicuous. A few consecutive days' visits to this part of the glacier, in early July, showed that a differential movement between adjacent strata seemed to be taking place (fig. 66). In order to test whether or not such was actually the case a point was selected upon the face 52 ft. above the valley floor, the ice slope being 45°, and six heavy spikes driven into the ice until their heads were flush with the surface. Three were thus placed in the base of the upper stratum and three corresponding ones in the upper part of the subjacent layer, the former projecting beyond the latter 19.7 in. July 21. Two days later, July 23, it was evident that the melting was greater upon the face of the upper stratum, in spite of which this now projected 24.4 in. beyond the lower. The spikes were now visited regularly each morning until August 3 and then reset after the amount of melting and apparent differential movement had been determined. The measurements were necessarily rough but they showed each day that the melting was greater upon the upper stratum, the average amount for each spike being 1.75 in., while that for the lower series was 1.53 in., or nearly ¼ in. in excess. Some sand and fine gravel, washed down from above, daily accumulated in the lee of the projecting upper layer and gave the appearance of a concentration of dirt in the upper part of the lower (fig. 66). When this dirt was small in amount it was observed that melting was accelerated; when greater, that melting was retarded. The upper stratum continued to gain slowly upon the lower and reached a maximum of 26.6 in. on July 27, after which it fluctuated slightly, the observations closing with it at 25.6 in. Time did not permit the verification of these results at other points where the same thing appeared to be occurring,

a. Front of Victoria glacier showing mouth of abandoned drainage tunnel

b. Across Lefroy glacier to Mt. Aberdeen

but there seemed to be no doubt but that the upper layer was moving bodily over the lower. This movement represents a shearing of the glacier itself, the shearing-plane lying between the adjacent strata, but not a shearing of the ice proper.

6. *Discharge.*—The conversion of ice into liquid during the heated season gives rise to surface streams upon the lower, slightly crevassed portions of the Lefroy and Victoria, which attain the magnitude of small torrents and do considerable cutting into the ice. In plate LX

Fig. 66.—Front of Victoria glacier showing stratification and shearing.

three such streams may be made out passing down the Victoria in the main longitudinal depressions and disappearing in crevasses or moulins. The water of these streams is clear and has a temperature of 32° F., or a small fraction above. Upon the glacier's right there is no visible marginal drainage at the present time, but upon the left there is, for a short distance, a vigorous stream and a small lakelet, the discharge from which disappears into the side of the glacier. These surface and marginal streams, along with others of subglacial origin, unite beneath the ice into a single brook which issues at a point between the nose and the oblique ice front, cascading over the rocks of the lately formed moraine. At times during the summer there is more or less discharge from here up as far as the reference boulder. Formerly the main discharge was through a tunnel, now clogged with frozen ground moraine, the mouth of which is shown in pl. LXI, *a*. The opening is 12 by 7 ft. at the lower end and extends obliquely backward under the ice for a distance of 160 ft. The fluted walls and ceiling show that it was at times completely filled with torrential waters (fig. 67). The temperature of the

FIG. 67.—Abandoned drainage tunnel, Victoria glacier.

water from the main exit varies from 32° to 33° F., rendered somewhat higher, undoubtedly, by the marginal stream. During the late spring and early summer the melting snows upon the mountain slopes contribute considerable warmer water to the glacial brook which empties into Lake Louise, but only immediately after rains do these side streams supply an appreciable amount of sediment. For a distance of some 600 ft. there has been built out into the lake a low delta of sand and gravel, the material for which, in the main, has come from beneath the glaciers which occupy the head of the valley. Determinations of the amount of sediment and volume of discharge across this delta were made at 9:00 A. M. and 6:00 P. M., after a week of minimum and another of maximum activity. Just at the glacier it was found impracticable to get the volume of water discharged, but the sediment carried per cu. ft. was found to be .230 oz. for the period of minimum melting, during which time .671 in. of rain fell near the nose. For the maximum period the amount

FIG. 68.—Stony till, left lateral moraine of Victoria glacier.

of sediment per cu. ft. was found to be .506 oz., with .03 in. of precipitation. During the former period there was delivered to the lake 73 cu. ft. of water per second and during the latter 93 cu. ft. The total amount of sediment brought from the glacier daily was estimated as six tons for the maximum period and about one-third this amount for the minimum.

7. *Surface Moraines.*—The two lateral moraines of the Victoria are made up essentially of a stony till, consisting of bruised and glaciated rock fragments, embedded in a matrix of bluish clay (fig. 68). Upon becoming saturated with water mud flows occur which carry forward fragments of considerable size (fig. 69). Over this material, which has been produced subglacially, there is a sprinkling of unglaciated, angular fragments, such as are more characteristic of surface moraines. This ground-morainic material for the left lateral has been manufactured beneath the extensive hanging-glacier which cloaks the entire eastern slope of Mt. Victoria, having

FIG. 69.—Mud flow from stony till in left lateral, Victoria glacier.

FIG. 70.—Stony till concentrated by surface melting. Lefroy glacier.

Double nevé field of Mitre glacier, showing bergschrund. Snow filled crevasse in the foreground

an area of perhaps two square miles and a vertical front of 200 to 400 ft. Fragments of ice, frequently as large as a city block, are crowded over the cliff and fall a distance of 1,200 to 1,500 ft., carrying with them more or less ground moraine and being ground into fragments by the force of the fall (fig. 64). The medial moraine also contains a certain amount of similar material which has been derived in the same manner from the hanging glacier upon Mt. Lefroy. Figure 70 shows this emerging through the snow and ice near the nose of Lefroy, from where it can be traced into the medial moraine. The right lateral is made up still more largely of this same stony till arranged in two or three sharply crested ridges, which may be followed continuously around the base of Mt. Aberdeen, where it passes into the right lateral of the tributary (pl. LX). There are a number of couloirs running up the side of Aberdeen, at the base of which detrital cones of angular debris are being built upon the ice but there are no ice fields upon the mountain (pl. LXI, *b*) to supply any ground moraine as in the two preceding cases. Many hours were spent in staring at these till ridges, diving beneath the great rubbish heap plainly derived from Aberdeen, and in trying to understand how the tributary could get its ground moraine upon its own back and arrange it in ridges parallel with its side. The matter remained a mystery until the last day of the five weeks' camp in the valley. A climb the day before up the side of Mt. Whyte to the Devil's Thumb revealed a feature which had hitherto escaped our observation, and the investigation of this furnished what we believe to be the real explanation of the puzzling phenomenon.

8. *Parasitic Glacier.*—The steep snow slopes upon either side of the Mitre give rise to two small ice streams which remain permanently covered with snow. These unite to form a single glacier (pl. LXII), which is also snow clad during the year but farther down becomes bare during the summer and reveals a very weak medial moraine. For this glacier the name Mitre, originally used by Allen, should be retained. It flows lazily down the valley for about a mile between Mts. Lefroy and Aberdeen, joins the Victoria and suffers much compression as previously noted. From the hanging glacier upon the eastern shoulder of Lefroy it receives a relatively large quantity of snow and ice which is heaped up along the base of this mountain and gives rise to another glacier which is not only nourished differently, but has a different direction of motion, a different set of strata and a different rate of velocities (pl. LXIII). It is for this overlying, parasitic glacier that the name Lefroy may best be used. Its movement is across the Mitre, but with reference to the valley

floor its motion is the resultant of its own motion and that of the Mitre beneath, so that it delivers its ground morainic material, derived from Mt. Lefroy, upon the Aberdeen side of the valley, but near the junction of the Mitre and Victoria (pl. LX; pl. LXIV, *a*). When the map is completed it will be possible to determine the relative motion of each member of this double tributary. The stratification of the Lefroy may be clearly observed in the crevasses, dipping at angles of 12° to 26° towards Mt. Lefroy. The ground morainic

FIG. 71.—Avalanche from hanging glacier on Mt. Lefroy.

material then in the right lateral of the Mitre and Victoria is derived from the shoulder of Mt. Lefroy, is avalanched into the valley below (fig. 71), incorporated into the newly formed strata, pushed across the surface of the Mitre and dumped upon its eastern edge, some of it arranged in ridges, parallel with the *front* of the Lefroy as well as the *side* of the Mitre, where it is slowly delivered to the Victoria. The feature observed from the Devil's Thumb which furnished the key to this rather complicated arrangement was a very sharply defined line which runs *lengthwise* of this double tributary (pl. LXIII).

MITRE AND LEFROY GLACIERS, SHOWING "DIRT ZONES" VICTORIA GLACIER, SHOWING FORBES' "DIRT BANDS"

9. *Dirt Bands.*—A close investigation of this line (fig. 72) showed that it marks the junction of two outcropping ice strata, the lower one containing a considerably larger percentage of foreign matter and that it is simply one—the most conspicuous one—of a series, the outcropping edges of which give rise to one type of "dirt bands."

FIG. 72.—Dirt zone, Lefroy glacier, confused with the dirt *bands* of Forbes. The latter show dimly upon the distant Victoria.

Such bands normally have a transverse direction upon the glacier and while these extend lengthwise of the Mitre they are normally located with reference to the Lefroy, to which they actually belong. The strata here are too thick to represent successive snowfalls, or even the entire year's precipitation, and such strata must correspond to short "cycles" of variable activity of the glacier making agencies. For this phenomenon the term "dirt zone" may be satisfactorily used.

When viewed from a distance of a half mile, to a mile, the Victoria, opposite its tributary, shows an entirely different and much more significant type of "dirt bands," the original bands of Forbes. Opposite the nose of Mt. Lefroy they appear as straight, transverse bands across the crest of a relatively steep ice slope, passing down which they gradually become more and more convex down stream at the center. For a short distance the bands may be traced, upon the Lefroy side, into crevasses which are swinging from a transverse into a longitudinal position. Some 23 of these bands may be made out (pl. LXIII), becoming more crowded together and more sharply bent before they are obliterated by surface melting. The explanation of this feature as given by Tyndall seems to be the correct one. As the ice flowing down a relatively gentle incline suddenly changes to one sufficiently steep, there is developed a system of transverse crevasses, because of the inability of the ice to yield suddenly without rupture. During the summer when the motion is most rapid there is produced either a single such crevasse or a series of parallel crevasses, more or less closely approximated. The sun rounds off the edges of the single crevasse and cuts rapidly into the exposed walls which separate neighboring ones (pl. LXIV, *b*). At the bottom of the slope, or upon the slope itself, when the crevasses are healed, there still remains a more or less well defined depression, into which atmospheric dust and the debris from the surface of the glacier may collect. During the winter there will be a fewer number of crevasses formed and either from the weaker solar action, or the protection afforded by the snow, the edges are not appreciably affected and the crevasses later are perfectly healed. The result of this action is that there is formed each year a depression and a ridge, each of which becomes more and more curved because of the more rapid central motion of the ice. Where the incline is steeper the motion is greater and the successive bands are farther apart, but as the ice becomes more sluggish upon the gentler slope the bands become more crowded. Each season, as the result of melting and rains, more and more material is washed into the depressions, so that they become better defined up to a certain point when, as a result of melting the surface acquires a uniform slope, the dirt becomes more uniformly distributed and the bands are obliterated. The method of formation here described is beautifully shown in the Deville glacier (fig. 72, *a*), situated in the Selkirks and here reproduced through the courtesy of Mr. Arthur O. Wheeler and the Canadian Topographic Survey.

Especial interest and importance is to be attached to this type of "dirt band," since it gives a clue to the actual, as well as relative, forward motion of the ice and a certain insight into the nature of this motion. Standing upon the Victoria it is possible to recognize about three-fourths of the bands which may be counted from a distance, and to determine approximately the successive intervals. Starting with the one at the base of the ice slope and measuring

a. The Lefroy glacier parasitic upon the Mitre. The morainic accumulation at the base of Mt. Aberdeen consists mainly of *ground* moraine, manufactured beneath the hanging glacier on Mt. Lefroy and carried *across* the Mitre by the Lefroy

b Formation of Forbes' dirt bands. Asulkan glacier

roughly from center to center, we have the following distances expressed in feet: 180, 138, 135, 159, 123, 114, 114, 102, 87, 102, 69, 84, 84, 72, 69 and 75. Upon the 26th of July, 1899, George and William Vaux marked the location of a certain large boulder upon this part of the Victoria and July 24, 1900, they found that it had moved 147 ft. This boulder was found to lie in 1904 opposite the ninth band in the above series, but somewhat to the west of the

FIG. 72 *a*.—Formation of Forbes' "dirt bands," Deville glacier, Selkirks. From summit Mt. Fox, looking eastward. Photographed by Arthur O. Wheeler, 1902. Canadian Topographic Survey.

maximum line of movement, as indicated by the form of the dirt bands themselves. In 1899 it should have been opposite what is now the fourth band and during the year following have moved across what would correspond with the fourth interval above or 159 ft. approximately. The above table of distances enables one to predict the approximate movement of these boulders during the next few years and gives a clue to the amount of longitudinal compression to which the ice must be subjected from year to year.

There remains still another striking feature, especially well shown upon the Lefroy, Wapta, Illecillewaet and Asulkan glaciers, to which the name "dirt band" is also applied and which may best be briefly described here for comparison with the preced-

FIG. 73.—"Dirt stripes," side of Illecillewaet glacier. The laminæ here would be conformable with the strata, providing the latter were present.

ing types, with which it has absolutely no connection. Much confusion has arisen in the thinking, the oral discussion and the literature because these three entirely independent features have not been clearly distinguished and separately named. The first two can be recognized to the best advantage at a considerable distance, this last must be seen at close range, along the margin of a glacier fairly free from coarse debris, and subjected to more or less surface melting. The surface here looks as though it had been swept with a wire broom, the strokes being very long and regular and parallel with the side of the glacier. The fine dirt, mostly wind-blown, is arranged in delicate, parallel streaks separated by similar streaks of relatively clean ice (fig. 73). The dirt is entirely superficial although one might think otherwise from the manner in which these bands run down into the crevasses (fig. 74) and cover the marginal

FIG. 74.—"Dirt stripes" and laminæ, Lefroy glacier, cutting strata at a high angle.

slopes. They may be so fine as to average but one-tenth of an inch in breadth, but are generally considerably coarser. This feature is dependent upon the laminated structure of glacial ice and is of importance in that it enables one to judge of the size, number and arrangement of the laminæ, directly from the surface. The outcropping edges of the "blue bands" of solid ice resist the action of the sun somewhat better than the white, vesicular layers by which they are separated. As a result there is produced a series of fine troughs, or furrows, separated by corresponding ridges, into the former of which fine dirt accumulates, reproducing in miniature the dirt bands of Forbes. It is suggested that the term "dirt stripes" be used for this phenomenon.

10. *Ice Dykes.*—A phenomenon not known to have been noted elsewhere, seen frequently upon the lower Lefroy in midsummer

and very sparingly upon one or two other glaciers, may be termed ice dykes. These consist of narrow crevasses, two to fifteen inches across, completely filled with columnar ice, the columns being arranged horizontally, in a double series, at right angles to the walls of the crevasse. In general the inner ends of the columns of each series interlock at the center and the crevasse is completely filled.

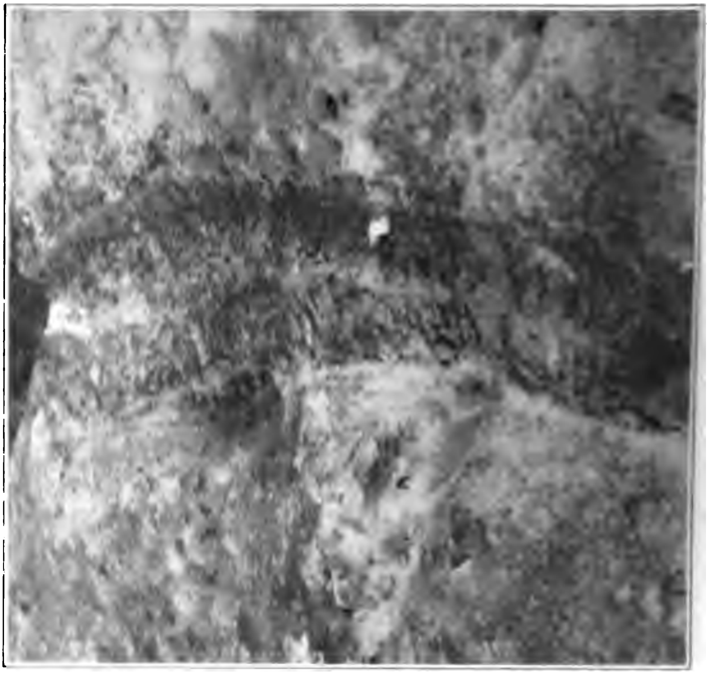


FIG. 75.—Ice dyke, Lefroy glacier.

In a few cases the columns do not meet and a narrow space is left, exceptionally the columns are more or less uniformly curved. These dykes are formed, in all probability, by crevasses becoming filled with water and then freezing from the walls inward, the columns forming at right angles to the freezing surface. The ice structure comes out imperfectly in a photograph (fig. 75). In some few cases ice dykes were noted which contained granular, instead of columnar ice, which must have had an entirely different history.

11. *Heat Reflection?*—Still another phenomenon not known to have been previously reported was observed as the snow was leaving that portion of the glacier usually bare in the summer. It consists of a large melted area upon the *northern* side of the boulders protruding

through the snow, which areas bear a certain relation to the breadth, height, shape and possibly position of the boulders themselves. The phenomenon was of very frequent occurrence upon the Victoria and Lefroy, and a suggestion of it was seen upon the surfaces of the avalanche slides about the margins, but all boulders did not show it. Figure 76 is of a white dolomite beginning to form a table, 5 ft.

FIG. 76.—Melted area on the *north* side of a surface block, Victoria glacier.

long and standing 20 in. high, with a melted area 5 ft. broad at the base, 70 in. long and with its longer axis N. 8° W. Another block is shown in fig. 77, a gray quartzite standing 10 in. high, with the melted area conforming in size and shape to that of the rock. The farther, right hand corner of the rock is lower than the general surface and the corresponding corner of the area is seen to be rounded and incompletely melted. The melted area, in all cases, is much greater upon the northern than upon the southern side of the rock. Ten of the axes of these areas, selected at random, gave an average of N. 25.5° W., magnetic, with rather less range than was observed in the axes of the glacial tables. The magnetic variation in this region, as obtained by the Canadian Topographic Survey, is N. 25° 5′ E., so that these areas are oriented with reference to the position of the noonday sun, and might have been used for determining approximately the magnetic variation. The natural inference is that the phenomenon is due to the reflection of heat from the upper surface of the boulder, this action being at a maximum when the sun is upon the meridian and reaching much farther out on the northern side than upon the southern, where the rays would strike but a short distance from the base of the rock. A tin reflector, such as is used for cooking, was found to give the same effect when left for a few days upon the snow. This explanation, however, was found to be unsatisfactory in certain cases where the upper surface of the boulder was inclined in the wrong direction to deflect the heat to the north, and so left the entire matter in doubt.

FIG. 77.—Melted area on the *north* side of a surface block, Victoria glacier.

12. *Ice Temperatures.*—A few observations were taken upon the temperature of the ice near the front, in the abandoned tunnel to which reference has been previously made. A hole was bored with an auger into the face of the ice, back 140 ft. from the entrance, and a standard minimum thermometer inserted. This was estimated to be 70 ft. back from the ice-foot and about 17 ft. from the actual ice face. During the week July 31 to August 7, the readings were 31.8°, 31.6°, 31.8°, 31.9°, 31.7° and 32°F., the maximum temperature of the air in the tunnel ranging from 31.4° to 33°F. Owing to the effect of

a. Non-conformity of the laminæ ("blue bands") and strata. Victoria ice front. Steel tape run out to 50 cm.

b. Lake Louise from surface Victoria glacier Ancient block moraines

the candle and warmth of the body it was found impracticable to get the actual temperature of the air in the tunnel at the time of observation and the maximum temperature, between visits, could be obtained only with the aid of a freezing mixture poured over the bulb of the thermometer.

13. *Lamination.*—Many observations were made upon the "blue bands" of the glaciers studied with the hope of shedding some light upon their position and direction in the ice and their relation to the granules and strata. In general it was found that they are well developed along the margins and front of the ice streams and that they are entirely independent of the stratification, cutting the strata as a rule at high angles. The laminæ and strata approach conformity more nearly along the side where no pressure is felt from either bed rock or lateral moraine (fig. 73), but where such pressure is apparently present the laminæ curve upward from the interior of the glacier and come to the surface at angles of 75, 85 and even 90°. Their outcropping edges extend parallel with the sides of the ice stream and generally give rise to the dirt stripes previously described (figs. 73 and 74). Towards the center they become less steeply inclined in a simple stream, and are rendered inconspicuous, or disappear at the surface. Under the medial moraine upon the Victoria they are highly inclined and somewhat fan-like. At the mouth of the tunnel they were found to average from 15 mm. to 19 mm. in thickness and to dip back into the glacier at an average angle of 9°, while the strata here average 26°. Plate LXV, *a* shows the nonconformity of the laminæ and strata. They seem to sustain a certain relation to the direction of maximum pressure and to represent neither ice-filled crevasses, shearing planes nor planes of stratification. Sufficient pressure from a different direction may induce a second set without obliterating the first and differential ice movements may give rise to irregular, contorted patterns (fig. 78).

14. *Block Moraines.*—From the present nose of the Victoria there extends across the valley and up obliquely upon the west side, an ancient moraine, composed of massive blocks of sandstone, quartzite and schist; lichen covered and partially disintegrated. There is a surprising scarcity of fine material except from the soil formation, in situ, which has given rise to a scanty growth of trees and shrubs. The material is arranged in two main heaps, one upon either side of the valley with a break between through which the glacial brook escapes. The blocks of stone are angular, practically unglaciated and show no signs of stream action. From 200 to 1,000 ft. farther down the valley a similar, but much more massive moraine, reaches

across the valley with a break at the center, most of the blocks being accumulated upon the western side where they attain a height of 40 to 50 ft. (pls. LXV, *b*, LXVI, *a*). These blocks are mainly quartzite, are dark and lichen covered and have but slightly disintegrated. Whatever fine material may exist it is entirely overshadowed by the massive blocks thrown tumultuously together. The largest one

FIG. 78.—Contorted laminæ, Wapta glacier.

observed split in falling and must have originally weighed about 970 tons. These also show only rarely signs of glaciation and were carried either *on* or *in* the ice and were not carried, or pushed along beneath it. Those blocks upon the eastern side of the valley came from Aberdeen, the Mitre and Lefroy; those upon the western side were derived mainly from Victoria. The central part of the glacier was not so heavily laden as the sides. No matter how long the ice front should now halt it would be incapable of forming such a moraine. One-quarter mile still farther down the valley there is a double detrital cone which partially covers a triple moraine, composed of fine and coarse material, with some till and not differing essentially from what is being formed at the present stage of the glacier (fig. 79). There was a time between the formation of this moraine and the present stage when the glaciers occupying the head

a. Quartzite blocks ot old Victoria moraine

b. Front of Wenkchemna glacier, showing a recent encroachment upon the forest

of the valley carried a different kind of load, presumably acquired in a different manner. The rings of growth in the spruce and fir of the Lake Louise region were found to average .884 mm. in thickness, with a range of .51 to 1.26 mm. in individual trees. The largest tree found growing upon the younger of the two block moraines gave a circumference of 221 cm. at a distance of 50 cm. from the base and should be approximately 400 years old. The largest spruce observed upon the older should be about 450 years old, while one just on the outer edge must be approximately 580 years of age. The last rings are added with extreme slowness owing to the

FIG. 79.—Brook from Victoria glacier cascading over an old moraine and double detrital cone.

relative reduction in leaf surface as the trees grow older, combined with the short growing season, the small amount of precipitation and the various disadvantages attendant upon having to live in a valley and especially one with a general north-south trend.

II. WENKCHEMNA GLACIER

1. *General Data.*—Nestling close in behind the northern base of that grand array of peaks for which the Canadian Geographic Board has recently adopted the name Wenkchemna Group, lies the Wenkchemna glacier. It occupies the southern half of the upper third of the Valley of the Ten Peaks, facing north while the valley itself

slopes east and then northeast. It is reached most conveniently from Laggan, via Lake Louise and Moraine Lake, at which place the Canadian Pacific Railway maintains a camp during the summer, located two miles from the glacier. The glacier is of peculiar shape, having a breadth of two miles and a length of one-half to one mile, presenting a total frontage of nearly three miles (pl. LXVII). It is fed by the snows which fall to the eastward of the continental divide, not differing greatly in amount from that of the neighboring Lake Louise valley, but there is no extensive collecting area, a small nevé

FIG. 80.—Debris covered surface of Wenkchemna glacier.

field and a correspondingly small amount of ice supplied the glacier. It has survived probably only because the surface and front are so heavily veneered with rock debris (fig. 80), from the nearly vertical cliffs at the back, that it is difficult to catch a glimpse of the ice. The peak of Deltaform, the highest crest of the Divide just here, is 10,945 ft. A. T., but the glacier itself lies mainly between 8,000 and 6,000 ft., according to the maps of Messrs. Wheeler and Wilcox.

2. *Piedmont Type.*—A general survey of the surface of the glacier shows that it is formed by the lateral coalescence of ten to twelve ice streams, each of which maintains its identity, more or less perfectly, from its origin to its nose and is separated from its neighbor

WENKCHEMNA GLACIER, A PIEDMONT TYPE. THE WENKCHEMNA GROUP OF PEAKS CONSTITUTES HERE THE GREAT CONTINENTAL DIVIDE

Photographed in 1903 from Mt. Temple by Arthur O. Wheeler, Canadian Topographic Survey

by a medial moraine. This is the piedmont type of glacier, only one other—the Malaspina—having thus far been described, which accounts for the peculiar form and behavior of this ice body. The component streams at the eastern and lower side are longer, better defined and flow northward, at right angles to the rocky wall in the rear. Toward the west they are deflected to the right and are less well defined because of the steep inclination of the valley floor and the interposition of a tremendous block moraine, too massive to be pushed aside.

3. *Frontal Changes.*—Attention has been called by George and William Vaux to the fact that portions of this glacier are encroaching upon the forest which skirts its front for a considerable distance, but no data have been available for determining the rate of advance. Dead trunks, from which the bark has fallen, are seen projecting from near the edge of the frontal slope (pl. LXVI, *b*), some of which were probably killed by a forest fire which swept through the valley 70 to 80 years ago. Other trees in similar position and condition still retain their dead boughs, without any evidence of fire, and seem to have been killed by the ice advance some years ago, since which time the glacier has advanced its frontal slope less than a dozen feet. This would indicate a very sluggish condition of the ice. In order to get something more definite by the close of the season, as well as for future reference, a series of eight sets of reference blocks was established, between which accurate measurements were taken with a steel tape. From August 9 to September 12, an interval of 34 days, no movement whatever had occurred at a point just east of the discharge brook. Passing westward along the front and up the valley, the next two stations showed a retreat of 1.2 and .7 in., due to the wastage of the ice beneath. The next two stations gave an advance of 1.9 in. and 1.3 in. The glacier was found to be again wasting away slowly as indicated at the next two stations by a retreat of 1.0 in. and 5.0 in. At the last station, nearly opposite Deltaform, a more marked advance had occurred, from August 14 to September 12, amounting to 14 in. Occasional rocks were here rolling down the frontal slope, giving evidence of activity beneath, and freshly cut trees were observed about this particular nose. It is thus seen that in glacial streams lying side by side, nearly their entire length, some are stationary, some in slow retreat and others advancing; a dozen different factors, at least determining in what way any particular stream will behave.

4. *Drainage.*—At the eastern and lowest side of the glacier there issues from beneath the frontal moraine a stream of perfectly clear

water (fig. 81) which seems to fluctuate but little during the day, or from day to day. The volume was estimated at about 90 cu. ft. a second and its temperature, during all hours of the day, ranged from 35° to 36° F. Less than a mile below, this stream enters Moraine Lake (pl. LXVII) where there is not even the suggestion of a delta, showing that the glacier is not only not eroding its bed now but that it has not done so for centuries. The temperature of the water and

FIG. 81.—Drainage stream from Wenkchemna glacier.

the regularity of its flow indicates that it is derived, to a considerable extent, from some source other than that of the melting of the glacier itself, such as the small side streams which enter the glacier and the drainage from Wenkchemna Lake (fig. 83). It is evident from the above data that we have here an exceptionally indifferent mass of ice and can understand how a glacier of such magnitude may be maintained by such a relatively small nevé area. The key to the situation is the high wall-like cliff which here has an east-west trend, entirely across the glacier, which not only shields the nevé and adjacent glacier directly from the sun but supplies it liberally and uniformly with a rock mantle for its further protection.

FIG. 82.—Ancient Wenkchemna moraine serving as a dam for Moraine lake.

FIG. 83.—Great block-moraine, Wenkchemna glacier, enclosing Wenkchemna lake.

5. *Lake Barrier.*—Entering the Valley of the Ten Peaks from the Bow valley and passing Moraine Lake, one encounters a somewhat puzzling morainic feature from which the lake has derived its pres-

ent name. This consists of a sharply defined heap of rock debris, about 400 ft. long, placed at right angles to the main axis of the valley and serving as a barrier (fig. 82). The lake has a double outlet, one across either end of this moraine, since with its flow divided, short season and no sediment, it can accomplish almost nothing in the way of deepening either outlet. The moraine increases in height, rather gradually toward the west, attaining a height of about 70 ft. and then ends abruptly, with no trace of a continuance across the valley. This feature has led some to consider the entire mass as a rock slide from the adjoining mountain slope. It is, however, a moraine such as a piedmont type of glacier is capable of making. This represents the place of halt of the front of the most eastern component stream of the Wenkchemna glacier at an earlier stage, the adjoining stream to the west reaching farther down the valley and, very probably, making a correlative moraine. The western end of this barrier moraine, while it was being formed, abutted against a solid ice wall, the removal of which by later melting allowed the debris to assume the "angle of repose." At the present time the easternmost component stream of the glacier is still relatively short compared with its neighbor and were the front to make a sufficiently prolonged halt there might be reproduced this same type of moraine.

6. *Block Moraine.*—Along the western front of the Wenkchemna glacier, for a distance of over a mile, there occurs a tremendous accumulation of huge morainic blocks of a red and brown sandstone, much disintegrated by the weather, but each roughly maintaining its own shape and size (pl. LXVIII, *a*). Near the upper end of the valley it must be a half mile across, reaching from the present ice margin to the foot of Pinnacle Mountain and surrounding the Wenkchemna Lake (fig. 83). Toward the east the moraine narrows up and an apparently older portion is soil-covered and forested. Nearly opposite Deltaform there is an accumulation of coarse, lichen-covered blocks at the edge of the ice, apparently part of a massive moraine which is overridden by the eastern half of the glacier. At the western side the ice has not been able either to mount this obstruction, or to push it ahead, and has been deflected down the valley, as previously noted. At an earlier stage the glacier must have extended quite across the valley and have been carrying a tremendous load of fragments of the peaks to the south. The formation of the moraine began, with which the ice continued in close touch, being unable to either override, or push it ahead, and there resulted a continuous deposit for a half mile, but with relatively little height.

a. Disintegrated sandstone blocks of old Wenkchemna moraine

b. Wapta glacier head of Yoho valley

Photographed by De Forrest Ross, Aug., 1904

Special attention was not given to the question of the *dual* character of this deposit but the writer's general impression is that the outer and lower portions are distinctly older, maintaining a heavy growth of lichens, some shrubs and larches. That portion of the moraine lying between Wenkchemna Lake and the present ice front has only a scanty growth of lichens and no herbs, shrubs or trees. It is possible that this morainic deposit is to be correlated with the two block moraines found in the Victoria valley, but of greater amount because of the better facilities for acquiring such a load and the greater friability of the bulk of the rock. The Wenkchemna at the present time is incapable of making such a moraine.

III. Wapta Glacier

1. *General Data.*—This great glacier, the largest of the series studied and known only since 1897, lies at the head of the Yoho valley and is easily reached from Field, via Emerald Lake. A day's trip, over a fairly good trail, up a most picturesque valley which is in the same class as the Lauterbrunnen and Yosemite, brings one to the summer camp maintained by the Canadian Pacific Railway. The glacier lies 3 to 4 miles beyond and with its great size and freedom from debris better meets the popular idea of what a glacier should look like (pl. LXVIII, *b*). Its nevé is collected in the depression surrounded by Mts. Habel, Collie, Baker and Gordon, and is a part of the great Waputehk Snow Field, lying just to the west of the continental divide. The ice cascades into the valley and, according to Habel, reaches an altitude of 5,680 ft., some 300 to 400 ft. lower than the Victoria and Wenkchemna, because of the greater volume. This increased volume of the Wapta results from the somewhat greater precipitation, probably equivalent to 30 ft. of snow, but mainly from the greatly increased size of the catchment basin. The main body of the glacier is much crevassed and impracticable for crossing, but the lower tongue has a fairly regular slope of 20 to 25° and, by cutting a few steps upon the western side, may be safely traversed. Upon the eastern side of the glacier there arises an embossment of rock, partially forested with spruce and fir, about which the glacier has built a sharply crested moraine. At a former stage of glaciation this embossment was completely overridden by the ice; later it was simply surrounded—a rock island in an ice stream—to which the term " nunatak " is applicable.

2. *Ice Distributary.*—Between 200 and 300 years ago the relatively narrow arm of ice which passed around this nunatak to the east separated from the main stream at its lower end and formed a minor

ice tongue, which has since been in slow but nearly steady retreat, wasting at the end, the surface and eastern side (pl. LXIX, *a*). The lower portion is so smooth and free from crevasses that three distinct drainage areas have been developed, two marginal and a central one, which possess large numbers of surface streams through which is conducted the water resulting from the melting of the ice and that which falls upon the surface as rain. The central area has

FIG. 84.—Three hundred-foot archway, Wapta glacier, from which issues the North Branch of the Kicking Horse. Photographed by De Forrest Ross.

developed a single trunk stream which passes lengthwise of the tongue, eroding a relatively large channel in the ice and delivering its waters to the glacial brook at the nose. The ice closely hugs the nunatak which it has been glaciating and "plucking."

3. *Drainage.*—Since its discovery the Wapta has maintained, just west of its nose, a great archway of ice, with a span of 250 ft. and height of perhaps 70 ft. (fig. 84). Through this there issues from the glacier the North Branch of the Kicking Horse, a rapid but shallow stream 240 ft. broad. This stream represents the wastage

a. Side branch of Wapta glacier, a kind of ice "distributary"

Sir Donald Mt. Bonney

b. General survey of peaks and snow fields from Roger's Peak, looking southeast Selkirks
Photographed by Arthur O. Wheeler, 1902. Canadian Topographic Survey

from the glacier itself, from its distributary and the drainage from the adjoining valleys. Its water is somewhat turbid, but not so much so as that which issues from the Victoria, and its temperature in mid-August averaged 34.25° F., varying a degree in either direction. During the summer a crevasse opens across the arch, permitting the ice to incline forward until it collapses finally and lies a heap of azure ruins until removed by water and sun.

4. *Ice Retreat.*—The nose of the glacier lies just east of the archway and rests upon bedrock. In August, 1901, independent marks were established by Miss Vaux and H. W. DuBois, from the former of which it was found that the ice here has retreated 111 ft. in three years, or at an average rate of 37 ft. a year. This measurement was made to the glacier itself and not to the detached block which has been the nose. Measured to this block the distance was 92.1 ft., giving an average of nearly 31 ft. a year, with a retreat of 23 ft. for the year 1903–4. The glacier seems to have been steadily retreating for a number of years, so far as may be judged from the weak development of terminal moraine. It should be noted, however, that even a considerable halt could produce only an inconsiderable moraine because of the small amount of debris carried.

Between the nose of the glacier and its distributary, upon the eastern valley slope, there occurs an interesting ridge of tree trunks, resting upon a slight morainic ridge and parallel with the present margin of the ice. It lies about 260 ft. up the slope and represents the work of an avalanche against the side of the ice when it occupied this position. The oldest living trees found in the path of this avalanche gave 47 rings of growth. This avalanche probably occurred between 1850 and 1860, since which time the side of the glacier has been retreating down the slope at the average rate of between five and six feet a year.

5. *Modified Moraine.*—Some 800 ft. down from the present nose of the Wapta there occurs a peculiar group of low knolls and crescentic ridges, lying to the east of the drainage stream, and connected with the weak, left lateral by faint ridges. Six concentric series may be made out, the ridges having their convexities directed down stream (fig. 85), diminishing in height and distinctness toward the glacier. These ridges vary in height from one to 12 ft. and the longest is in the form of a semi-circumference with a radius of 20 ft. They all possess the smoothed, rounded outlines of drumlins, but lack their profile and arrangement. They consist of a core of ground morainic material with a thin dressing of sand and gravel. They have apparently been produced about the nose of the glacier,

the ice getting a *purchase* upon the thin covering of ground moraine and by a series of minor advances and retreats pushing it up into concentric ridges and detached knolls. Later a more general advance permitted the ice to override the structures, but so lightly that they were simply smoothed and rounded without being completely destroyed, and the surface dressing of sand and gravel was applied

FIG. 85.—A suggestion of Wisconsin-morainic topography; in front of Wapta glacier.

as the ice finally retreated. In miniature, with their smooth contours and undrained basins, they strongly remind one of the morainic topography left by the latest ice sheet in America and Europe.

6. *Glacial Granules.*—In both the Wapta and Illecillewaet glaciers, on account of their size, unusually good material is to be obtained for the study of the granules, of which the glacier from its nevé to its nose is known to be composed. About the lower end of the Wapta these granules range from 5 to 70 mm. in maximum diameter and seem to average between 20 and 30 mm., becoming gradually smaller towards the nevé. These granules are irregular polyhedrons with their faces so firmly pressed together in general that no interspaces occur and the ice appears homogeneous and of uniform color.

Thin sections of such ice, however, when examined with the polariscope, reveal the component granules and each is seen to be a single, although incomplete crystal, giving the ice mass the appearance of very coarse marble. Sections cut in various directions from the ice near the nose of the Wapta, Illecillewaet, Asulkan and Victoria glaciers, showed a tendency toward a vertical arrangement of the principal optic axis. In *horizontal* sections of such ice from one-fourth to one-third of the granules remained dark when revolved

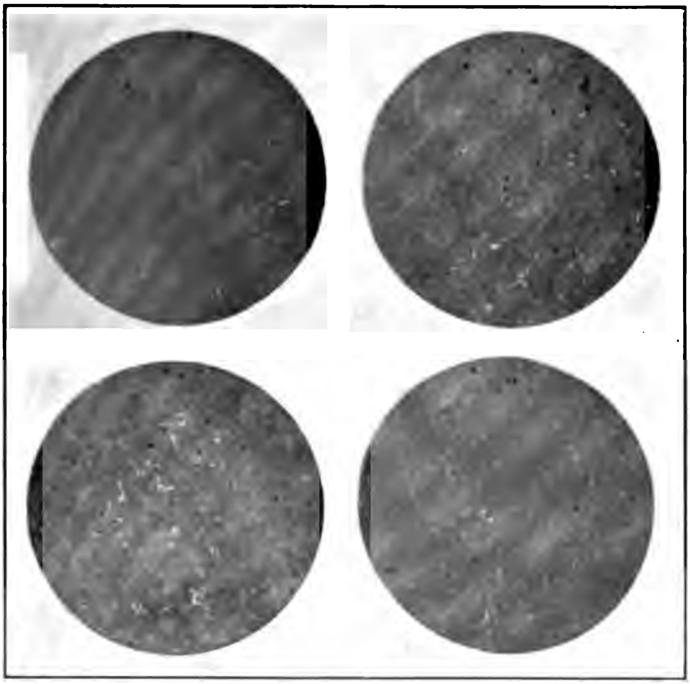


FIG. 86.—Glacier capillaries, uninjected. Wapta.

in the polariscope. From this it was concluded that there exists a tendency towards orientation of the granules, which has been affirmed by some and denied by others.

7. Capillary Structure.—Glacial ice which has not yet begun to melt either externally or internally is solid and firm and contains simply the air cavities enclosed in the processes of granular growth. Such ice is not penetrated by water, or colored solutions, except to very slight extent. When internal melting begins there is opened up a more or less continuous network of delicate capillaries, situated at the lines of junction of three, or more, granules. These are circular in cross-section and, judging from the way water passes along them, quite free from air. Their walls reflect the light strongly and give the appearance of a network of silver threads, more or less perfectly outlining the granules. From beneath the ice it was possible to get limited areas of them upon a photographic plate and these are reproduced in fig. 86. By using a strong solution of potassium permanganate it was found that they could be beautifully injected, the solution entering the ice in a few minutes to a depth of several feet. Such injected capillaries from the Illecillewaet glacier are

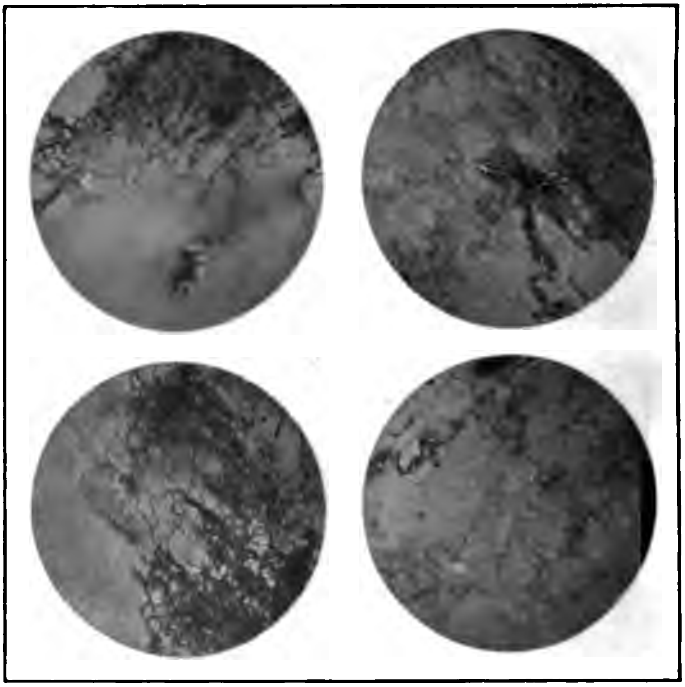


FIG. 87.—Glacier capillaries, injected. Illecillewaet.

shown in fig. 87. Upon the faces of crevasse walls and ice caves these tubes are frequently seen in longitudinal section, forming a pattern by which the granules are outlined. As melting proceeds, within the ice, the capillaries become irregular and crinkly, spaces are opened up between the adjoining faces of neighboring granules, and the original network becomes obliterated. With this increased reflecting surface the beautiful blue color of the ice gives way to white and in places causes it to again resemble the nevé. A small amount of pressure now, or a blow, will cause the ice to crumble into its component granules, the surfaces of which are seen to be covered with a system of fine ridges and rows of points, about 1 mm. apart and resembling, more than anything else, the markings upon the ball of one's thumb. Internal melting of the granule gives rise to the "Tyndall melting figures," originally figured by Agassiz and described by him as flattened air bubbles.

8. *Extensive Plucking.*—A peak, as yet unnamed, lying between the nose of the glacier and Mt. Balfour, is made up of a succession of curved, concentric strata, the upper of which are a dark limestone, dipping to the southwest at an angle of about 30°. This peak

FIG. 88.—A "plucked" mountain peak, head of Yoho valley.

was overridden by ice moving from the north, which ripped off bodily the strata, leaving the more resistant portions, overlapping and projecting (fig. 88). Upon the upper surfaces and upon either side of these remnants the disrupted blocks were completely removed, but in their lee they accumulated as shown in the figure. Evidently the entire mountain peak has been reduced in height to a considerable, but unknown amount, by the process of "plucking."

9. *Block Moraines.*—Not realizing at the time the significance of this type of moraine, no special study was made of them in the Yoho valley. Two massive ridges are crossed but they are soil covered and forested and their real nature was not investigated for lack of time. They may be mountain spurs or rock slides, but are more probably moraines; rather too old, apparently to be correlated with the block moraines previously described. If they are not really

present in this valley their absence may be satisfactorily accounted for by noting the scarcity of rocky cliffs from which the blocks might have been derived.

IV. Illecillewaet Glacier

1. *General Characteristics.*—Passing from the Rockies to the Selkirks, the next chain to the west, there are marked evidences of the increased precipitation. The mountains are more completely forested and less rugged and the extensive snowfields send down hundreds of ice tongues which reach a considerably lower altitude

Fig. 89.—General view Illecillewaet glacier, Sept., 1904.

than in the Rockies. The glacier in the two Americas which has been visited by more people than any other is the Illecillewaet, reached in a half hour, over a good trail from Glacier House. It is fed by a snow-ice field covering from five to six square miles, lying to the south of Mt. Sir Donald and having an elevation of 8,000 to 9,000 ft. (pl. LXIX, *b*). The lowest part of the rim of this collecting basin is upon the north side and through this the ice spills over and cascades into the valley, forming innumerable crevasses and seracs, and reaching an altitude of 4,800 ft. General maps of the region have been made by Green, Bell-Smith and Wheeler and large scale maps of the lower extremity by the Vaux Bros. and Penck, but no

ILLECILLEWAET GLACIER, 1888.

Photograph by Notman and Son, Montreal.

ILLECILLEWAET GLACIER, 1904. FROM SAME VIEW POINT AS PLATE LXX

detailed map, or general description, of the entire glacier has yet been prepared. In the size of its collecting area, freedom from debris, and crevassed condition it is similar to the Wapta, and like it has been in steady retreat for a number of years (fig. 89).

2. *Ice Retreat.*—For some years previous to 1887 the Illecillewaet was stationary and engaged in building a small frontal moraine. In 1887 the front was photographed by the Vaux Bros. and its position

FIG. 90.—Rôche moutonnée, Illecillewaet glacier.

with reference to a massive block definitely determined. One year later it was photographed by Notman and Son, as well as others, as it was starting to withdraw from the moraine (pl. LXX). Since this retreat began numerous reference blocks have been established and the rate determined from time to time and published. The rate of retreat has thus been found to vary according to the season. In the entire 17 years the ice front has receded 603.5 ft., measured horizontally, or at an average rate of 35.5 ft. a year; the recession for the past year being but 11 ft. when measured to the nose which has shifted to the west (pl. LXXI). The ground moraine thus exposed constitutes a "boulder pavement," the boulders at the last having been so lightly ridden by the ice that they were slightly striated, without being disturbed. Beneath the margin of the ice the boulders are seen to produce flutings upon its underside, some of these extending 70 to 80 ft. beyond the boulder by which they have been produced. The melting about the nose and sides of the glacier concentrates the relatively small amount of dirt enclosed in the ice. This was found to contain about 14 per cent. organic matter, enough to make it dark colored and to give it an offensive odor when set away moist in a warm room. For several years back the glacier has been uncovering a mass of bed-rock upon the west side.

FIG. 91.—Block-moraine made conjointly by the Illecillewaet and Asulkan glaciers. Strewn with avalanched timber.

This is a quartz schist with beds of coarse conglomerate and here are to be seen good examples of polishing, scratching, rôches moutonnées (fig. 90), lee and stoss phenomena, plucking, chatter-marks, knobs and trails, basins and troughs.

3. *Block Moraines.*—Some 1,400 ft. from the present nose of the glacier there extends across the valley an ancient moraine, about 400 ft. broad, made up of massive blocks of quartzite. These blocks are blackened with lichens and carry enough soil to support trees of considerable size. A cut spruce with a circumference of 128 cm. gave 243 rings of growth. A hemlock near at hand has a circum-

ference of 320 cm. and, by calculation, should be 447 years of age. About one-third of a mile farther down the valley, where the Asulkan and Illecillewaet valleys meet, a still more massive moraine of this same type is seen. The blocks are very coarse, scarcely any fine material showing, and consist almost entirely of quartzite, the largest seen being estimated to weigh 1,250 tons. The moraine swings out from the base of Glacier Crest, obliquely across the valley, from 200 to 300 ft. across and from 60 to 70 ft. above the valley floor, most of the material being concentrated upon the west side of the stream. The blocks are blackened with lichens, but have disintegrated so little that the moraine supports only a scanty growth of timber and shrubs (fig. 91). Upon its eastern side it is nearly covered with shattered tree trunks which were swept down from the side of Mt. Eagle by an avalanch, showing one way in which soil may be acquired by such a moraine. The largest tree found growing between this moraine and the preceding was estimated to have been 520 years old when it died and, from the condition of the wood and bark, to have been dead about 30 years, giving a total of about 550 years.

V. Asulkan Glacier

1. *General Characteristics.*—This glacier, or rather two glaciers, to which the name has been applied, lies at the head of the Asulkan valley, some five miles from Glacier House. The nevé region lies between the Dome, Castor and Pollux and Leda upon the west and the Asulkan Range upon the east, separating it from the Illecillewaet nevé (pl. LXXII). The mass of ice supplied is considerably less than in the preceding glacier and the main ice stream reaches an altitude only of about 5,600 ft., the nevé lying between 7,000 and 8,000 ft. Portions of this nevé are beautifully stratified. The inclination of the bed seems quite regular and in only one or two places is the ice badly shattered by irregularities. Toward the nose the inclination of the surface is quite gentle, only about 6°, increasing finally to 25°. The glacier is transporting comparatively little material at the present time, but has sharply crested lateral moraines, with cores of stagnant ice.

2. *Frontal Changes.*—Points of reference for the study of the frontal movements of the main Asulkan stream were established August 12, 1899, by George and William Vaux. Last year, September 17, 1903, the nose had pushed 13½ ft. beyond this line, plowing into the ground moraine and overturning boulders. One of the stones marked by the Vaux Bros. had evidently been pushed forward some 14 to 15 ft. Upon August 27, 1904, the nose was 12½ ft.

beyond the Vaux line and still plowing into ground moraine, indicating a very slight change for the entire year.

3. *Drainage.*—The drainage from the two ice streams is not strong, but more turbid than either the Illecillewaet or the Wapta, indicating a greater relative amount of subglacial erosion. From the main Asulkan two streams issue, one upon either side of the nose, fluctuating some from day to day and during the day itself. This fact, as well as the temperatures averaging 32.7° F. and 32.2°

FIG. 92.—Left Asulkan moraine shedding its rocky covering and exposing the ice core. East side.

F., would indicate that this water is derived almost entirely from the melting of the ice.

4. *Morainic Core.*—It is difficult for the ordinary visitor to believe that the high, sharply crested embankments, lying parallel with the main axis or sides of the glacier, are in reality *ice* ridges with only a comparatively thin dressing of rock fragments. The left lateral of the Asulkan is showing, in a most interesting manner, the real structure of such a moraine and the passage from a single ridge into a double one. About a quarter of a mile back from its lower end it begins to shed its rock cover, the debris sliding down and forming a ridge upon either side. The eastern side is not completely

Mt. Donkin and Asulkan Pass Leda Pollux Castor

GENERAL VIEW OF ASULKAN GLACIERS AND SNOW FIELDS

bare (fig. 92), but the western side is entirely so and we see an ice ride 25 to 30 ft. in height (fig. 93). This exposure of the ice permits its rapid melting, even below the level of the ice upon which the two ridges are now resting and instead of the ice ridge we find farther down the valley a depression, with a small morainic ridge upon either side.

5. *Block Moraines.*—From the outermost of the two block moraines of the Illecillewaet there curves across the mouth of the Asulkan valley a similar type of moraine, made up of identical blocks in the same condition. From their position it is evident, as pointed

FIG. 93.—Left Asulkan moraine shedding its rocky covering and exposing the ice core. West side.

out by Penck, that the Asulkan glacier operated conjointly and simultaneously with the Illecillewaet. The bulk of the material is deposited upon the eastern side of the valley and appears to have been derived mainly from Glacier Crest, Lookout Mountain and the Asulkan Range. In retreating up its relatively narrow valley, instead of a single prolonged halt, it made two or three minor ones and built coarse moraines, at the same time distributing coarse material along the valley floor.

6. *Rate of Retreat.*—From an examination of a number of trees, of the different varieties found in the Asulkan and Illecillewaet valleys, it was found that the average breadth of an annual ring of

growth is here 1.14 mm., as compared with .884 mm. in the Lake Louise valley. Some exceptionally large spruces and hemlocks are found at the entrance to the Asulkan valley, two of which, by calculation, appear to be 525 and 598 years of age. Toward the head of the valley the trees become smaller and younger and the rings of growth somewhat coarser. It is about two miles from these trees up to where the Asulkan brook enters the narrow valley and has excavated some 30 to 40 ft. of schist since the retreat of the glacier. One of the largest firs here shows 161 rings of growth and a still larger hemlock near is not far from 250 years of age. So far as such data can be depended upon, it would seem that the Asulkan withdrew up this portion of the valley in about 350 years and at an average rate of 30 ft. a year. From the schist cut to the present nose of the glacier the valley opens and for this quarter mile the rate would presumably be less, perhaps not more than one-half or one-third as great, owing to the greater mass of ice to be melted away. Similarly the retreat from the outermost block moraine into the narrower portion of the valley would also probably be slow.

VI. Significance of the Block Moraines

Since this entire report is simply a summary of the most important observations made no resumé in closing need be attempted. It is desired, however, to point out here what seems to the writer, in his present state of knowledge, to be the significance and importance of this special variety of terminal moraine. While in the field they were a perplexing puzzle and not until the snow-clad Rockies had disappeared upon the western horizon did even a plausible explanation present itself. The theory of their formation will need to be tested by observations in many of the valleys adjoining those studied. As has been pointed out they are made up of very coarse fragments of the surrounding cliffs and peaks, the actual size of which is not so remarkable, knowing what a transporting agent a glacier is, as the *average* size of the fragments composing the moraine. The finer materials, commonly present in a terminal moraine, are completely overshadowed by these massive blocks and such fine material was apparently not present from the first. These blocks were carried on or in the ice, not beneath nor pushed ahead and appear to be in a double series in four of the five glaciers selected for study. None of the glaciers observed could now make such a moraine, no matter how prolonged the halt. Periods of excessive weathering would certainly load the glacier with much fine, as well as coarse material. The prevalence of the phenomenon prevents our resorting to the rock slide for an explanation. Proceeding thus by a process of elimination the conclusion seems forced upon us that there is here evidence of a double seismic disturbance of the entire region. Coarse fragments, more or less weathered to start with, were shaken loose from the overtowering cliffs and peaks and dropping into the nevé, or upon the ice, were not ground into fragments as they ordinarily are when they descend into the valley. The protection afforded the ice by this material brought about a halt in the frontal retreat then in progress and the blocks were concentrated into two moraines more or less separated. As soon as the bulk of the material, resulting from each disturbance, had been deposited the glacier then resumed its slow retreat.

If this is the correct explanation then it may be predicted that glaciers favorably situated for receiving such loads, as the Dawson, Geikie and many others, will show similar block moraines, providing they have not been overridden, or destroyed by later advances of the ice, as is partially true in the case of the Wenkchemna. Remnants of ice streams, which at the time of the disturbances were tributary to other main trunks, would in no case have independent moraines of such a type. Neglecting the differences in the time of transportation, due to the varying velocities of the several glaciers as well as the different distances that the material must be transported, these moraines in the various valleys may be correlated in time. If the approximate age of any one set can be determined we shall have the data for estimating the average rate of recession of all those glaciers having such moraines, as well as ascertaining the approximate date of the seismic disturbances. The oldest trees found growing upon the younger of the two moraines in the Illecillewaet and Lake Louise valleys are 447 and 400 years of age respectively. In the Asulkan valley a rough estimate would be obtained by adding to 250 years, the time required for the glacier to retreat about 1¾ miles at the average rate of 30 ft. a year. This would give about 560 years, the excess over the preceding estimates probably being required for the formation of sufficient soil to allow the trees to start their growth upon such coarse moraines. The younger of the two block moraines may be regarded as between 500 and 600 years old and, allowing for the transportation of the material, the earthquake, if such really occurred, probably happened during the thirteenth century. The outer moraine is probably 150 to 200 years older than this inner.

Through the kindness of Mr. Frank B. Taylor the writer's attention was called to a rather remarkable earthquake which seems to have severely affected Canada and the adjoining portions of the United States in 1663.

It is described in the Jesuit Relations,[1] and in spite of the apparent exaggeration and superstition there seems to have been wrought widespread geological changes, many times greater than would have been needed to load the glaciers with their rocky burden. The following quotations will serve to show the severity of the disturbance which continued from February until August.

"On the fifth of February, 1663, toward half past five in the evening, a loud roaring was heard at the same time throughout the length and breadth of Canadas."

"According to the report of many of our Frenchmen and Savages, who were eye-witnesses, far up on our River, the Three Rivers, five or six leagues from here, the banks bordering the Stream on each side, and formerly of a prodigious height, were leveled—being removed from their foundations, and uprooted to the water's level. These two mountains, with all their forests, thus overturned into the River, formed there a mighty dike which forced that stream to change its bed, and to spread over great plains recently discovered."

"New Lakes are seen where there were none before; certain Mountains are seen no more, having been swallowed up; a number of rapids have been leveled, a number of Rivers have disappeared; the Earth was rent in many places, and it has opened chasms whose depths cannot be sounded."

"On level ground, hills have arisen; Mountains, on the other hand, have been depressed and flattened. Chasms of wonderful depth, exhaling a foul stench, have been hollowed out in many places. Plains lie open, far and wide, where there were formerly very dense and lofty forests. Cliffs, although not quite leveled with the soil, have been shattered and overturned."

---

[1] Thwaite's Translations, Vol. XLVII; pp. 37–57; 183–223.

PHOTOGRAPHING ON WOOD FOR ENGRAVING

By THOMAS W. SMILLIE

Honorary Custodian, Section of Photography, United States National Museum.

Up to about the year 1868, pictures which were to be engraved on wood had to be transferred by hand to the block in a reversed position, and as this work was laborious, the artist who made the original picture generally left the transferring of it to the block, to be done by a mere copyist, who was very likely to take a fine spirited original and make a characterless copy of it, and in scientific work often reproducing the subject with such inaccuracy that the illustration when completed was perfectly useless. This led to the suggestion that the photographer should take the place of the copyist, and various photographic methods were tried, beginning with the carbon transfer which made a beautiful copy in the desired reversed position, but very misleading to the engraver on account of the thickness of the film, then the albumen-silver method which made the wood pithy, next the bromo-gelatine which was with a minumum amount of gelatin fairly successful, but which with the necessary amount of washing caused large blocks to swell and crack.

At this time acting upon a suggestion in one of the journals that collodion transfers might be used on wood, I tried it, but found that as used at that time it would not do.

I used the process however as a basis for experiment and finally by adopting the alkaline silver bath which has little solvent action on the haloides on the collodion surface, making a thick collodion with very little iodide and bromide, so as to prevent the lighter shadows and middle tones from blocking up, thus enabling me to give short exposures and force the development, and in fact doing everything to produce a picture on the surface of the film so that no pyroxylin should intervene between the picture and the block (otherwise the picture would be carried away when the film was dissolved). I finally perfected the process and produced a picture of exquisite delicacy, having no more body than a pencil drawing upon the wood. This is the process which has been in use in the Smithsonian Institution since 1869.

For fifteen or twenty years I prepared nearly all of the illustrations for the Smithsonian Institution and its bureaus in this way, and also for several of the government Departments, but when the cheaper photo-engraving processes were perfected, they supplanted wood engraving, and this method dropped out of use.

Now that there has been a revival of wood engraving I have thought that the publication of this method might benefit those interested in such work. I will begin with the silver bath which should be prepared in the following manner:

Water	100 c.c.
Nitrate of silver	8 grams.
Iodide of potash	2 decigrams.

Add oxide of silver, stirring until an excess remains undissolved, then set in the sun for five or six weeks, when it should be taken in and decanted. This is called an alkaline silver bath and must not be acidified.

COLLODION

Alcohol 95 per cent	60 c.c.
Sulphuric ether	40 c.c.
Ammonium iodide	7 decigrams.
Ammonium bromide	2 decigrams.
Pyroxlin	1.5 grams.

DEVELOPER

Water	100 c.c.
Ferrous sulphate	2 grams.
Glacial acetic acid	13 c.c.

TONING BATH

This should have an acid reaction.

Water	100 c.c.
Gold chloride pure	2 decigrams.

FILM SOLVENT

Sulphuric ether	100 c.c.
Alcohol	50 c.c.

Obtain plate glass without scratches and immerse in nitric acid, then wash and set it in a rack to dry. Take a negative of the object to be engraved, place it in the window as if to make a transparency except that the glass side should face the lens, coat the glass with the collodion and immerse in the silver bath just long enough to sensitize it. Expose in the camera as for an ordinary transparency, develop until all detail appears by reflected light, but keep the whites perfectly clear, wash thoroughly and fix in

Water	1 liter.
Cyanide of potash	10 grams.

Wash thoroughly and tone through to the glass with the before mentioned gold solution and wash and place the plate in water acidified with sulphuric acid. This will loosen the film. When free from the glass, raise it up, holding it in place on the plate with the thumbs and rinse under the tap.

Place an ordinary glass now in a tray with water, turn the picture down upon this and allow it to float off the plate glass.

Center the film now on the glass in the water, raise the glass up, holding the film in position with the thumbs, now take a piece of thin paper, immerse it in the water and lay it down upon the film.

We will suppose that you have in the meantime coated the block with flake white with just enough Heinrich's gelatine to make it adhere to the block. This will be enough to make the picture also adhere.

Raise the paper up now with the film upon it and lower from one side upon the block in such a way as to exclude air bubbles.

Put a piece of moist blotting paper upon it and place in a letter press and put the pressure on for about two minutes, then remove it, strip the paper off in such a way as not to lift up the film and remove the surplus film from the edges and turn the block face down in the mixture of ether and alcohol; this will remove the pyroxylin and leave the image on the wood.

This process also makes an exquisite collodion transfer on paper.

THE LIFE HISTORY OF THE ANGLER

By THEODORE GILL

One of the most interesting and remarkable fishes of the North Atlantic is that whose cognomen in books is angler, but which has received a number of true vernacular names in the countries bordering the waters in which it lives; it is scientifically known as *Lophius piscatorius*. It is the best known representative of a large group (order or suborder) of fishes named Pediculates. The essential characteristics of this group may be first indicated.

I

In almost all osseous fishes there are four bones (actinosts) set apart for the base of each of the pectoral fins, and these are generally short and imbedded in the flesh so that the pectoral fins appear to rise directly from the sides of the body close behind the head. In some remarkable forms, however, which in most respects agree with the Acanthopterygians, the pectorals originate from arm-like bases resulting from the elongation of the actinosts after their reduction in number to three or even two; these form pseudobrachia or false arms. With this character is associated the reduction of the branchial apertures to narrow foramina in the axils of the pectoral fins, or rather their supports or "pseudobrachia." The usual headbones are not manifest externally, being covered by the skin, but almost all are present, though much modified. There are, however, no suborbital bones. There are soft dorsal, anal, and caudal fins presenting no unusual features, but the spinous or first dorsal is more or less modified, one tendency being the production and recumbency of the foremost interspinal bone on the front of the head, and the consequent position of the ray over or near the snout, and in one genus (*Malthe*) this tendency is carried to such an extreme that, the forehead being horizontally extended, the dorsal ray is rooted *under* the snout! The ventral fins, when present, are "jugular," but in one polymorphous family (Ceratiids) there are none. The order, according to the best recent authorities, includes five families—Lophiids, Antennariids, Ceratiids, Gigantactids and Malthids. It is the first that is typified by the angler.

The family of Lophiids, or anglers, is distinguished for its large and much depressed head, the mouth directed upwards, the branchial apertures mostly in the lower axils of the pectorals, in some continued round the pectorals in front; the pectorals with two actinosts and little geniculated but directed outwards, the ventrals moderate, and the first dorsal represented by a fin of three spines and, in advance of them, by three free spines of which the first is generally longest.

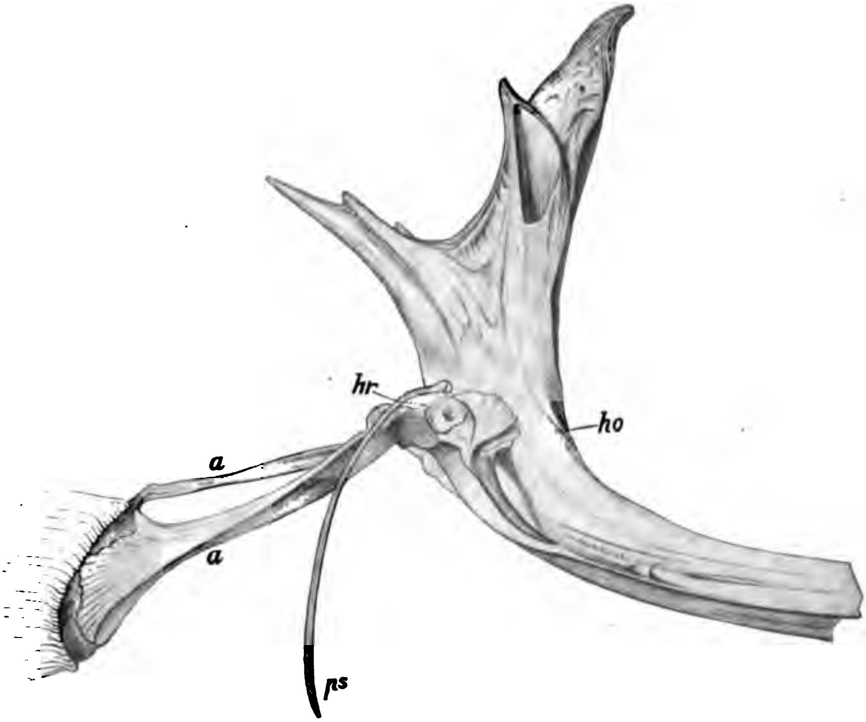


FIG. 94.—Shoulder girdle of the angler, showing the pseudobrachium or false-arm with its 2 actinosts (*a*), the hypercoracoid (*hr*), hypocoracoid (*ho*), and postscapula (*ps*) as well as proscapula or cœnosteon. (After Mettenheimer.)

While the head, as a whole, is much depressed, there is no fundamental difference between it and that of a pediculate with a compressed head, such as that of an ordinary Antennariid. The cranium itself is narrow and the breadth results from the flaring outwards of the opercular apparatus. In the earliest stages, indeed, the head is compressed and then the young fish lives near the surface of the sea and it is only when it takes to the bottom that the depressed form is assumed.

For a long time only a couple of species of this family were known, but successive deep-sea explorations have brought to light quite a number, and the last reviser of the group—C. Tate Regan—in 1903 recognized as many as thirteen distributed among three genera—*Lophius, Lophiomus* and *Chirolophius.* All the species have a very strong family likeness, all having a wide mouth, gills on the lower halves of the first three branchial arches only, the fourth being without, pseudobranchiæ, the three epipharyngeal bones of each side coalescent (the first being undeveloped), and the first two dentigerous, but the last edentulous.

The generic differences are notable; *Lophius* and *Lophiomus* have the "gill-openings entirely below or behind the pectorals," while *Chirolophius* has them "partly below, partly in front of and above the pectorals"; *Lophius* has as many as 27 to 32 vertebræ, while all the others have only "about 19 vertebræ." The *Lophius piscatorius* may attain a length of three feet or more, but most of the species, so far as known, are less than a foot long.

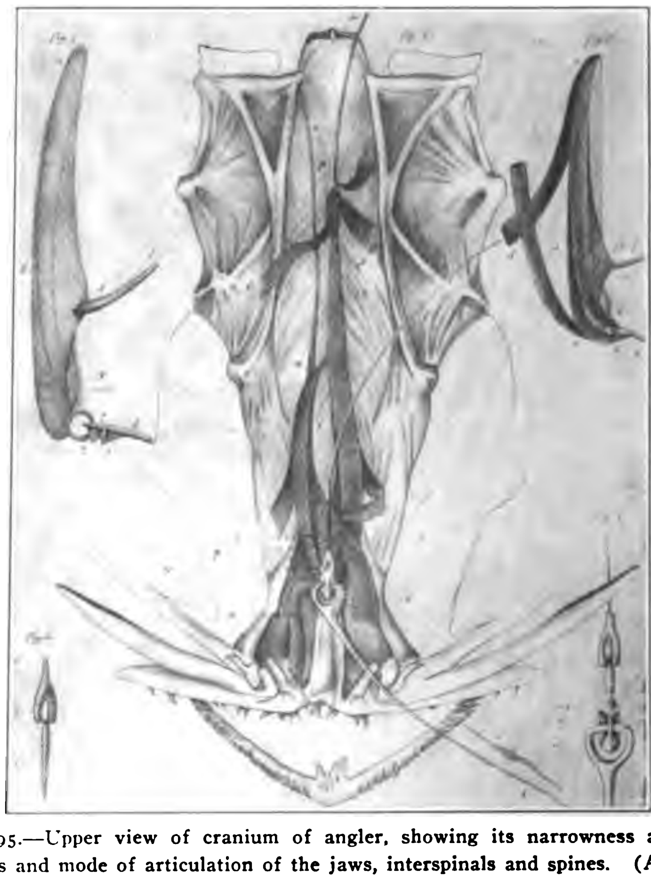


FIG. 95.—Upper view of cranium of angler, showing its narrowness and the relations and mode of articulation of the jaws, interspinals and spines. (After E. M. Bailly.)

II

The name *angler,* which is almost universally used for the fishes of this genus in books, is really a book-name, and not one in general use among shoremen and fishermen. It was, indeed, especially coined for the *Lophius piscatorius* by the English litterateur and naturalist, Thomas Pennant, in 1776; in his British Zoology, as he says, he "changed the old name of *fishing frog* for the more simple one of *angler,*" simply because he did not like the former, which was one of the popular names. But there was no lack of real vernacular names. In England, besides *fishing-frog,* there are *frog-fish, toad-fish, pocket-fish, monk-fish, nass-fish, sea-devil, devil-fish, wide-gut, wide-gap* and *kettle-maw,* and these are supplemented by other local names in Wales, Scotland and Ireland. In America another set of names replaces the English ones. The most common along the Massachusetts coast is *goose-fish;* in Rhode Island *bellows-fish* is in use; in Connecticut, *molligut* may be heard, and in North Carolina *allmouth.* One who has looked into the vast cavity behind the jaws will concede the aptness of the last name.

Although Angler is not a true vernacular name for the *Lophius,* it is an analogue of names in popular use in other countries, as Pecheur or Poisson-pecheur at Bordeaux, Pescatrice at Rome and some other places in Italy, and Petricia at Malta. The modern Greeks have adopted the Italian name with a modified form (Peskandritza or Peskantritza) into their own language; a true Greek word, Batrachopsaro (Frogfish) is also in vogue at some places (Patras). Among the Ancients it was known as the sea frog, the Greeks calling it Batrachos o alieus; the Romans, Batrachus marinus.

III

The angler's horizontal as well as vertical range is great, and covers a large portion of the North Atlantic on both sides, where the temperature may range between 32° and 60° F.—perhaps even higher. On the eastern side it is common in the Mediterranean and along the western coasts of Europe, becoming less common along the Scandinavian shores to the northward; it wanders upward, however, to the North Cape and the Faroe Islands.[1] Along the American coast it is most common in the comparatively shallow waters of New England, and in deeper water about Nova Scotia and Newfoundland to the north, and as far to the south as the Caribbean Sea. "There is some reason to think that south of Cape Cod it retreats to deep water in summer."

[1] If the identification be correct, it even reappears around South Africa.

While thus quite common along many coasts in rather shallow water, it appears to be at home in deep water. In the cold water under the tropical surrounding Barbados, at a depth of 209 fathoms; at another place, from "a depth of 365 fathoms" (according to Goode and Bean), specimens were dredged.[2]

IV

It is emphatically a bottom-fish, as its depressed form and uplooking eyes sufficiently indicate. It is also addicted to solitude, living apart from its fellows. In some selected nook, perhaps "hidden among seaweeds or stones"; perhaps "buried in the mud, with only the mouth and the gill-openings free," it "lies in ambush for its prey." At depths where algal vegetation no more thrives, it doubtless lies exposed or half-buried in the bottom, for the light is dim and extraneous concealment not much required. According to Day (evidently guided by Couch), in England "during the summer and autumn it resides near the shore where, by means of its pectoral fins, it forms for itself a cavity in the sand," or, should the ground be rough, it lies as if dead, while "its floating filaments, kept in motion by the tide, decoy other fish, and the angler's tendril is no sooner touched than the game is caught." Saville Kent, who had excellent opportunities of observing a large individual in the Manchester Aquarium (1874), was struck by its adaptation to its natural environments, and has given a graphic description of it.

"Commencing with generalities, one of the most striking features that first attracted notice in this specimen was the remarkable likeness of the animal's head to a mass of rugged rock—the irregular outline formed by the prominent ridges of its upper surface, and the excessive projection of the massive lower jaw, especially favoring this simile. Following up the idea still farther, the illusion was found to be carried out to an extent altogether marvelous to contemplate. This prominent lower jaw in itself formed a natural rocky ledge springing from the parent mass. Along its lower margin are dependent, in the most highly developed state, those singular lobulate processes which extend in a straight line backward to the creature's tail. The size and shape of these processes vary considerably, though generally following a more or less leaf-life contour, and one between every two or three being much longer than its neighbors. As far as I am aware, no attempt has yet been made to explain the purpose

[2] The deep-sea Caribbean fishes are not in the National Museum and the writer is unable to confirm the identification. They probably belong to a different species.

or function of these appendages; but to one accustomed to hunting for marine treasures at low tide on a rocky coast line, their resemblance to the small flat calcareous sponges (*Grantia compressa*), ascidians, zoophytes, and other low invertebrate organisms which fringe the lower margin of every conspicuous ledge, is strikingly suggestive. The next point we arrive at is the wonderful apparatus upon its head, with which the animal has been supposed to lure on its prey to destruction. It consists of two erectile filaments, the foremost of which is produced at its extremity into a membranous digitiform expansion. According to the books, this expanded membrane owes its especial attractive qualities as a bait to fish in its vicinity to the glittering metallic colors which play upon its surface. As far as I can ascertain, however, by both personal observation and that of others, no such distinctive coloring really exists, the membrane sharing the sombre hues of the general surface of the body. Following out our rock simile, these organs yield another point remarkably favorable thereto; the foremost filament, with its digitiform membrane, is the facsimile of a young frond of oar-weed (*Laminaria digitata*) in both shape and color; and in the tendril behind it we have a repetition of the same with the blade of the frond, as it were, worn away by the current of the ocean. Our rock, however, is not yet clothed with all the growths that contribute to perfect its mimicry of nature; for where we least expect it—that is, in the animal's eye—we find the most extraordinary mimicry of all. These organs are very large and prominent, the iris being conical in shape, of a yellow ground color, with longitudinal stripes of a darker shade, while the pupil, commencing abruptly at the summit, is of so jetty a hue that the aspect of the whole is that of a hollow truncated cone, resembling, with its longitudinal stripes, the deserted shell of an acorn barnacle, and with an amount of exactness that is apparent to the most ordinary observer. We have here in this fish, then, the most perfect possible embodiment of a rocky boulder, with its associated animal and vegetable growths. Lying prone at the bottom of the ocean among ordinary rocks and debris, it might well pass muster as an inanimate object, and the other fish on which it preys would approach it with impunity, and never discover their mistake until too late to escape from its merciless jaws. Esconce the animal snugly, however, in the crevice of some precipitous submarine cliff, and the illusion is more perfectly complete. No strategy need now be exerted by the voracious fish to attract his prey; he has only to lie close and quiet, letting his tendrils sway to and fro in the passing current like the weeds around him, and the shoals will approach, browsing the vegetation, or pursuing their crustaceous diet right into his very mouth. And that such surroundings as the foregoing are most congenial to the angler's tastes is abundantly evinced by the habit of the specimen in the Manchester Aquarium. He is ever slinking off to the rock work, and establishing himself so closely in some snug corner that it requires, notwithstanding his large size, a considerable amount of diligent search to detect him."

Conceding the perfect aptness of Kent's remarks, the story is yet only half told. There can be little question that the foremost spine of the angler, with its leaf-like or worm-like appendages, does really attract fishes, in so far as they are moved by curiosity at least to approach so near that the angler can leap upon them and engulf them in its capacious mouth. Two thousand years ago and more the adaptation for concealment as well as for capture, by attracting other fishes, was recognized by naturalists and philosophers. Cicero of old, in his work on Natural Theology, looking at one side only of the question, called attention to the ability of the angler (or sea frog as he called it) to conceal itself and yet attract other fishes for its consumption.[1] Could those other fishes be heard, they would tell a story against providential interference!

Not long after the observations made by Kent in England, even better ones were made by the German naturalist Schmidtlein on individuals kept in captivity in aquaria at the zoölogical station of Naples. His account is here translated from the original German:

Lophius embodies, so to speak, a living angling apparatus. Unfortunately there is not much to record concerning its habits in captivity that might be considered as a contribution to the already known characters, for it is so peculiarly adapted for its dark mud-bottom, that it can never endure the confinement in our bright, well-lighted prisons with the clean sand for more than a few days. It lies for the most part on the bottom in perfect apathy without burying itself in the sand, and stares with its big dull, glazed eyes straight before it, while the jaws of the enormous mouth open a little and close at every breath, and the lobed barbels on the chin swing back and forth. At times it raises the "hooks" on the head and lets the terminal lappets play, or it yawns and changes the color of its dull mud dress into a lighter or darker shade. It never takes any food

[1] Ranæ autem marinæ dicuntur obruere sese arena solere, et moveri propè aquam, ad quas, quasi ad escam, pisces cum acesserint, confici a ramis, atque consumi. De Natura Deorum, I, 49.

either voluntarily or by force. If it is made to feed it will spit out the morsel again. Before death the skin of the tail generally peels off, and the tail putrefies from the point upwards.

The sea-devil attains considerable size, and the aquarium several times possessed specimens more than a meter in length; the latter, however, could not survive even as long as the smaller fishes.

V

As one of the popular names, *Allmouth,* indicates, the fish is well fitted to ingest food, and its instinct is coordinate with its capacity. It is, in fact, a most voracious carnivorous animal, and, so far at least as flesh is concerned, omnivorous. It is indiscriminate, too, for in Massachusetts some " annoy the fishermen by swallowing the wooden buoys attached to the lobster pots," and a man " caught one by using his boat-anchor for a hook." A bottom fish, it naturally feeds largely on fishes living on or near the bottom, such as flatfishes, gurnards, sculpins, sea-ravens, dog-fishes and small rays, as well as crabs, lobsters, squids and starfishes. Impartiality in accepting what offers itself was manifest in one from which Buckland took " two mary-soles, one common sole, one piked dog-fish, 1 ft. 6 in. long, three moderate-sized crabs, fourteen five-fingers, and one whiting." Observations were made on three Massachusetts individuals taken in 1897 and 1899 and recorded by Edwin Linton (1901). One " had in its stomach a large quantity of mud which was rich in mollusca, annelids and small crustaceans." Another, " a small specimen, had in its stomach a winter flounder almost as large as itself." A third had " fragments of fish." The first observation is of unusual interest as an evidence of what the fish may do when unsuccessful in securing larger prey.

Its search for food is by no means restricted to the bottom, however, for though a slow and clumsy swimmer, by stealthy approach, it succeeds in surprising not only active fishes, but even birds and mammals swimming on the surface. According to R. Q. Couch (1847), in Cornwall, it also " frequently rises to the surface of the water in the summer and autumn, and lies basking in the sun."

Its success in capturing large birds swimming on the surface, is commemorated in a name most in vogue along some parts of the coast (goosefish); several " have been known to swallow live geese." A fisherman told G. Brown Goode that " he once saw a struggle in the water, and found that a goose-fish had swallowed the head and neck of a large loon, which had pulled it to the surface and was trying to escape. There is authentic record of seven wild ducks having been taken from the stomach of one of them. Slyly approaching from below, they seize birds as they float upon the surface."

A number of analogous instances of capture of birds might be given. Birds quite as large as a goose have been taken, such as the loon and gull (*Larus argentatus*). Reliable Cape Cod fishermen, Captains Nathaniel E. Atwood and Nathaniel Blanchard, assured Dr. D. H. Storer that " when opened, entire sea-fowl such as large gulls, are frequently found in their stomachs, which they supposed them to catch in the night, when they are floating upon the surface of the water." Storer was also "informed by Captain Leonard West, of Chilmark, that he had known a goose-fish to be taken having in its stomach 6 coots in a fresh condition. These he considered to have been swallowed when they had been diving to the bottom in search of food."

By far the most valuable studies of the food of the angler were made by T. Wemyss Fulton and published in 1903. No less than " 541 anglers of various sizes, caught mostly in the Moray Firth, Aberdeen Bay, and the deep waters of the Shetlands were examined." Fulton's studies were for the purpose of ascertaining " the amount of destruction caused by this species among the food fishes." It appears that, " so far as the anglers investigated " were concerned, " the principal food consisted of whitings, sand-eels, haddocks and common dabs, and in smaller amount of herrings, solenettes, and others." The " proportions differ on the different grounds, and at different seasons." A noteworthy circumstance is that " the great majority of the fishes found in the stomachs were small, even when the angler was large." The rarity of large fishes was supposed by Fulton to point " to their greater caution than when younger." Besides fishes " the only other organisms found in the stomachs were a shore-crab in one and a swimming-crab in another, and cephalopods in thirteen."

Another noteworthy characteristic of the angler is the tenacity with which it holds on to what it has seized. A couple of anecdotes told by Jonathan Couch (1862) will illustrate. " Mr. Thompson, of Belfast, records an instance where a gentleman discovered an angler near the shore, and presented the butt-end of his whip to it, when it seized and held by it until it was thus drawn on shore. An angler of large size was also discovered in shallow water by a couple of boys who were in a boat, where they happened to be without oars. But with the intention, perhaps, of annoying the fish, they loosened a board that lay along the bottom of the boat and thrust it within the creature's expanded jaws, which immediately closed upon it. A struggle then commenced, but so firmly did the fish retain its grasp, that it suffered itself to be dragged out of the water and secured."

Another feature of the fish is the slowness of its digestive powers. Couch has also aptly illustrated this characteristic, where the angler's skill was utilized by other fishers. "On one occasion there were found in the stomach of an angler nearly three quarters of a hundred herrings; and so little had they suffered change that they were sold by the fisherman in the market without any suspicion in the buyer of the manner in which they had been obtained. In another instance there were taken from the stomach twenty-one flounders and a dory, all of them of sufficient size and sufficiently uninjured to make a good appearance in the market where they were sold." Still more apt evidence of the slowness of digestion has been given by James T. Linsley (1844). A large angler (3 ft. 8 in. long), caught near Bridgeport, Conn., "continued alive out of water about 24 hours," and when cut open, Linsley "took from its stomach subsequently, a large half pail-full of fishes, of various species, such as tom-cods, cunners, bass-fry, etc.; of the latter, some were as perfect as when swallowed, notwithstanding the lapse of time mentioned."

VI

Of all the remarkable characteristics of the angler, perhaps the most remarkable are the manner in which the eggs of the female are consigned to the waves and the subsequent development and metamorphosis of the young. As much as 22 or 23 centuries ago, at least, the manner of oviposition was known to Greek fishermen and briefly noticed by Aristotle.

Leaving aside his irrelative and speculative remarks, he declared that the sea frog lays its eggs in a bunch near the shore. Not until quite recently was more information communicated, and then in a land unknown to the Greek philosopher.

About the end of summer the fishes seek shallower water and the inhabitants of the depths advance upwards; the sexes must then consort together, but in what manner and what rites of marriage are performed is unknown; the result, however, is, that about the time indicated "the fishermen on the New England coast often notice a substance floating on the water, which they term 'a purple veil,' the precise nature of which has caused much speculation on their part, and which answers singularly well to its designation." S. F. Baird, in 1871, became interested in the accounts he heard and sought to determine the origin of the "purple veil." He found one "which presented the appearance of a continuous sheet of a purplish brown color, 20 or 30 feet in length, and 4 or 5 in width, composed of a mucous substance which was perfectly transparent, to which, as a whole, a purple color was imparted by the presence of specks distributed uniformly throughout the mass to the number of about thirty or more to the square inch." The little specks were embryonic fishes "moving vigorously in their envelope, but without any appreciable latitude of motion, or change of relative position to each other." Baird could not identify the little fishes but it happened that Alexander Agassiz had shortly before observed and investigated the veil with its contents and determined it to be the product of the angler. In 1882 Agassiz published the results of his investigations and a remarkable history was disclosed, which has been supplemented by the more recent observations of Prince, McIntosh and Masterman.

FIG. 96.—Three eggs embedded in the gelatinous membrane in which they are laid; magnified. (After A. Agassiz.)

The "violet veil," in fact, is a great communistic cradle for the large family of a single mother angler. It is, according to Agassiz, "an immense ribbon-shaped mucous band, from two to three," or it may be five, "feet broad, and from twenty-five to thirty feet," or even, according to Prince, thirty-six feet long. "It looks at a short distance like an immense crape. The mucus is of a light violet gray color and the dark black pigment spots of the young *Lophius,* still in the egg, give to the mass a somewhat blackish appearance. The eggs are laid in a single irregular layer through the mass, usually well separated by the mucus in which they float." The color of the veil must vary from light when first issuing from the mother *Lophius* to dark when the eyes of the larvæ have become conspicuous. The eggs may be as many as a million or more. (Thompson estimated 1,420,000 and Fulton, 1,345,848.) Each egg is about a twelfth of an inch or two millimeters in diameter. Thus the earliest stages of development are passed and when the larva has burst its shell envelope it immediately leaves the veil and begins life free on the surface of the sea.

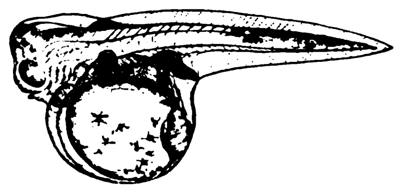


FIG. 97.—Young angler taken out of the egg just previous to hatching. (After A. Agassiz.)

The newly hatched young, as Agassiz well says, "it would be difficult to recognize" as the embryo of the angler. It would, indeed, be impossible to do so without extraneous information. It is an elongated, mouthless and almost shapeless being with the yolk still forming nearly half its bulk and with simply a continuous fin fold.

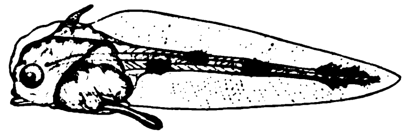


FIG. 98.—Young angler not long after hatching; the yolkbag has entirely disappeared. (After A. Agassiz.)

About a week later it has obtained a mouth, a dorsal ray has been evolved, and long spatula-like ventrals as well as short broad pectorals have been developed.

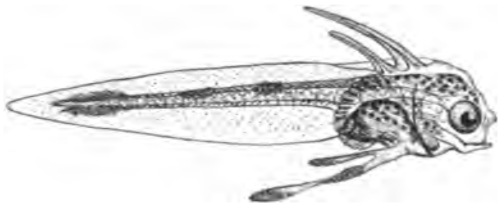


FIG. 99.—Young angler with 2 elongated dorsal rays and rudiment of third, and 2 large ventral rays. (After A. Agassiz.)

In about a fortnight or little more a second dorsal ray has become manifest, the pectorals have developed incipient rays, and the ventrals show two rays.

At a considerably later period the early form is still retained but the head is more pronounced, the mouth and jaws better defined, and

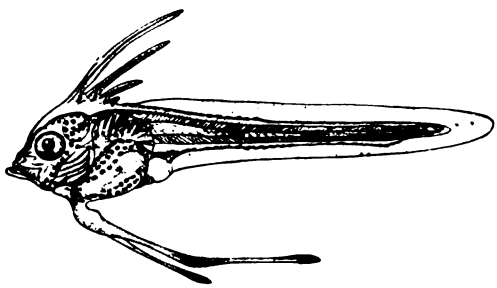


FIG. 100.—Young angler showing still greater increase in length and number of anterior dorsal and ventral rays. (After A. Agassiz.)

the four distinct dorsal rays over and behind the head are manifest; the two ventral rays have become longer. There is an indication in the lower fold of the future caudal and where the notochord is to be tilted up.

Later still the continuous fold has been broken up and distinct rayed dorsal and anal fins are developed, but the caudal is " hetero-

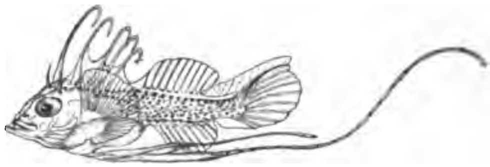


FIG. 101.—Young angler in oldest pelagic stage measuring 30 millimeters in length, seen in profile. (After A. Agassiz.)

cercal." The anterior dorsal has been increased by a short ray in front and another behind and all are more elongated and ray-like than in earlier stages. The pectorals have become well developed and the ventrals enormously elongated so that, when seen swimming from above the little fish reminds us of a long-tailed butterfly.

FIG. 102.—Young angler of oldest pelagic stage seen from above. (After A. Agassiz.)

When the angler has reached this stage, it has become a respectable fish. It does not, indeed, look at all like its mother but nevertheless an ichthyologist, perfectly familiar with the fishes of the North Atlantic, would have no difficulty in recognizing it as the young of the angler. The numbers of rays, and more especially the six nearly or quite free anterior dorsal rays, are characteristic and distinguish the fish from all others. The condition and mode of development of these free rays are indeed noteworthy on account of their early appearance, inasmuch as the anglers are not in other respects radically differentiated from other families of pediculate fishes.

Development still goes on and the caudal fin becomes homocercal, the other fins still better defined. The head grows disproportionately, the ventral fins become much reduced and the pectorals less so, the foremost dorsal spine grows out beyond all the others and the second to sixth, arrested in development, are much shorter, and the four median caudal rays become forked. A regular fully developed Angler is the outcome.

The next noteworthy stage in development is in the way of perfecting the fins, especially the rays, and the isolation of the three foremost dorsal rays and their advance forwards so that the first arises from the snout. The tag-like appendages are concurrently developed along the sides of the body, the edges of the lower jaw and opercular apparatus, and the dorsal spines. By this time the

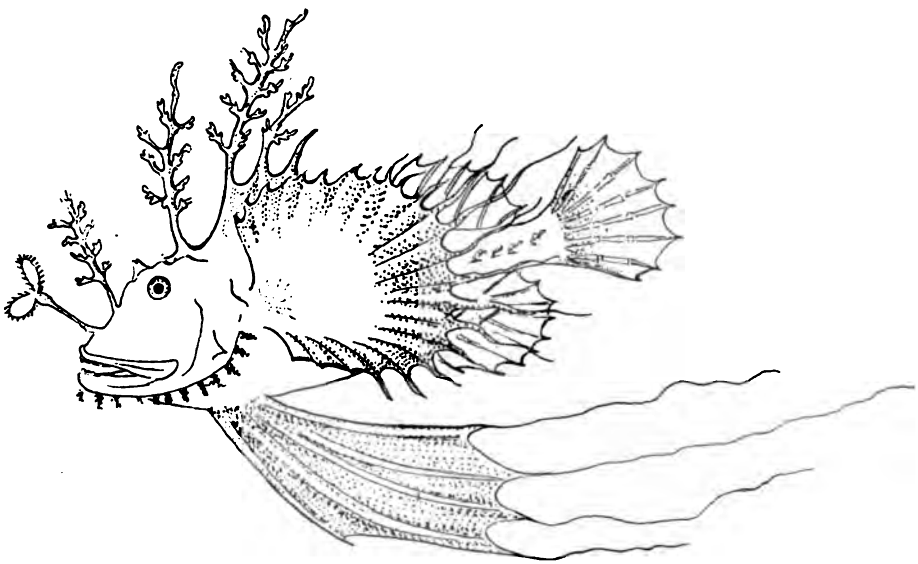


FIG. 103.—Young angler with most of the characteristics of adults but larger pectorals and ventrals, and less flattened head. (After Rüppell.)

little angler is two or three inches long. The ventrals are still very long but all the rays are developed and the head and body have not yet assumed the much depressed form characteristic of the adult.

When the young fall to the bottom they are supposed "to frequent rocky algæ-covered ground where they can have a shelter and also suitable food." Few are ever taken by the dredge or trawl even in ground where the old are abundant. It is only when they become older that most of them leave such secluded nooks and come out into the open.

The growth of the angler has been especially studied by T. Wemyss Fulton (1903) based on the examination of large series. When six months old, the "mean" length is $6\frac{3}{8}$ inches (5–$8\frac{3}{8}$), when "1 year and 6 months," it is $12\frac{1}{2}$ inches (9–$15\frac{18}{16}$), and "when 2 years and 6 months," it is 18–$18\frac{1}{2}$ inches ($14\frac{1}{2}$–21–22).

"When 3 years old, supposing a little less than the same rate of increase continues—and in fishes growth is not usually much reduced in rapidity before the period of maturity is reached—the angler will measure approximately 21 inches in length, and when 4 years old about 26 or 27 inches. The information as to the size at which maturity is first attained is not extensive, but males may be found ripe at the size stated. Females probably do not become mature as a rule until over 30 inches in length, and the facts point to the males first reaching maturity when 4 years of age and the females when 5 years."

As such an angler, it passes its life, year after year. It becomes "a huge unshapely creature, and is of a soft, gelatinous, and flaccid consistence. Its mouth is enormous," and its "antipathy to action is strangely contrasted with the enormity of its appetite, to satisfy which it has recourse to stratagem in the capture of its prey."

VII

The angler is not usually ranked among food-fishes and is generally unceremoniously rejected; nevertheless it is said to furnish excellent meat. According to Donovan (1808), "the flesh of this fish is white, and having, it is said, the same flavor as the common frog, is eaten in many countries as a delicacy." Couch (1863) reported that it "is a delicious dish." In Scotland, Parnell long ago (1839) had declared that "the flesh is considered good, especially near the tail," and McIntosh and Masterman (1897) state that "it comes under the category of a food-fish and is treated in a similar way to the wolf-fish. The head is cut off and only the trunk is sent into the market. This is sold under the name of 'croan' and sometimes of john dory, a name that of right belongs to a very different fish."

In Massachusetts, where it is most frequently caught, according to Storer (1855), "no use is made of this fish, as its liver contains but little if any oil; and its flesh has no fat. This," he thought, "is a singular fact, as most, if not all, other fish have either fat in their livers or in their flesh." But although not eaten now, it was by the aboriginal Americans, as is evidenced by the discovery by Wyman (1868) of osseous remains in a shell-heap in Maine (Crouch's cove).

A singular superstition is entertained in some parts of Sweden (Bohuslan) according to Malm and Smitt. "It is so feared by many that the tackle is cut as soon as the 'monster' reaches the surface; and its captor hurries home in order to get there, if possible, *before the misfortune portended by the monster overtakes him.*" The extreme of misfortune—death—is believed by some to be indicated. Nilsson tells that the Swedish fishermen on the banks "believe that on board the vessel on which an angler is taken, some one is *feg, i. e.,* doomed to die soon. They therefore never or hardly ever take the angler on board, but prefer to cut the line and thus lose the hook with the fish."

An anemometrical faculty is attributed to the angler in Massachusetts. According to Storer, " among the fishermen in some parts of the bay, there is a common saying, ' when you take a goose-fish, look out for an easterly storm.' "

VIII. Relations of the Angler

Although the angler is the only species of its family in northern seas, quite a number are found elsewhere, and especially in deep seas.

The most primitive genus, if we may take the position of the branchial apertures for our guide, is *Chirolophius.* This has, as C. T. Regan has recently (1903) shown, the " gill openings partly below, partly in front of and above the pectorals." So far as known the vertebræ are only 19 or thereabouts. The typical species, *C. naresii,* was made known from a specimen " taken at the Philippines at a depth of 115 fathoms." Other species are the *C. moseleyi, C. murrayi,* and probably *C. gracilimanus, C. mutilus,* and *C. lugubris,* all inhabiting the depths of the Indian and neighboring oceans. Another Lophiid found off the coast of Central America is also supposed to belong to the same genus and designated *C. spilurus.*

A genus agreeing with *Chirolophius* in the number of vertebræ (19) but having the gill openings below or behind the bases of the pectorals, as in *Lophius,* is *Lophiomus* which is now limited to a single species—*L. setigerus,* occurring in moderately deep water from Japan to the Cape of Good Hope.

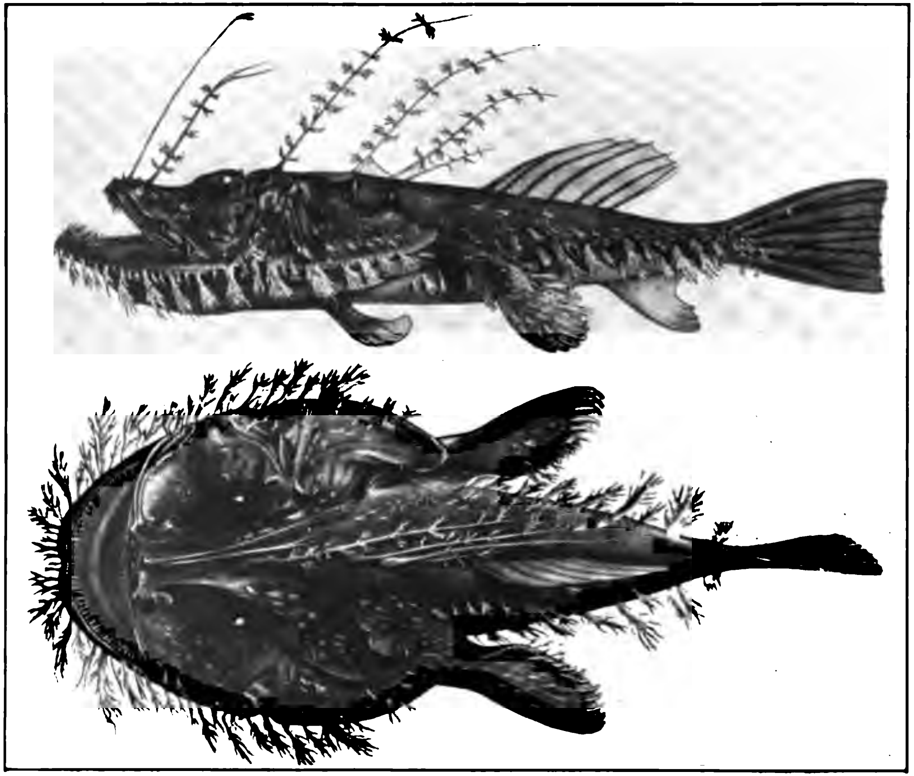
The genus *Lophius* still includes, besides the common angler, *L. piscatorius,* a species as yet found only in the Mediterranean sea, *L. budegassa,* and two others. One is the *L. litulon* which has been found along the coasts of Japan and extends further northward than the *Lophiomus setigerus;* another has recently (1903) been described as *L. vaillanti* of which specimens were found in the Atlantic around " the Azores and Cape Verde islands at depths of 460–760 meters."

A Lophiid said to have no vomerine teeth and consequently regarded by some as a distinct genus—*Lophiopsis*—is retained in *Lophius* by Regan.

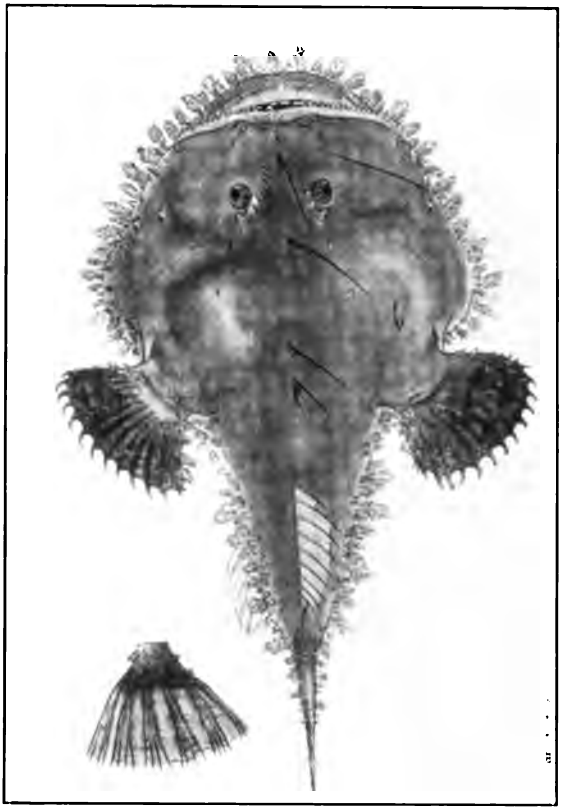
Of the extinct relatives of the angler little is known. No remains have been found in the pliocene or eocene formations but in an upper eocene bed of Monte Bolca (Italy) an imperfect fossilized body of a species was obtained more than a century ago and considered by Volta to belong to the recent *Lophius piscatorius;* later (1835) it was named by Agassiz as a new species of *Lophius* (*L. brachysomus*). As A. S. Woodward (1901) has remarked, "it seems to be rightly placed here." It is probably otherwise with the so-called *Lophius patagonicus* named by Ameghino (1899). This was based upon teeth from a Patagonian bed supposed to be of cretaceous age.

IX

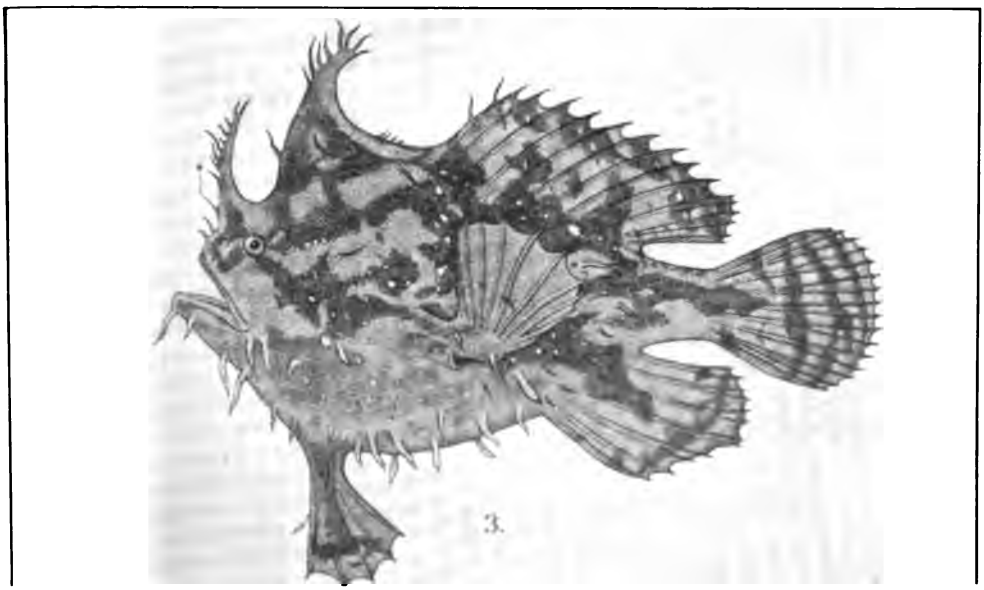
The nearest relations of the Anglers—the Antennariids—differ very decidedly in being compressed rather than depressed. This difference might lead the observer to assume that the shape of the head was equally different, but such is not the case, and the characteristic is chiefly superficial. The difference may be compared to that between an old-fashioned table with two folding sides, open and closed. The Angler is analogous to the table with the sides upraised and level with the middle; the Antennariid, to the table with the sides inclined to right angles with the middle. The cranium is essentially similar in both and the difference in physiognomy is the resultant of the spreading outwards of the opercular and other lateral bones in one form (the Angler), and the folding downwards or compression of the corresponding elements in the other (the Antennariid). While such are the facts, however, there are nevertheless many minor characteristics or details of structure which are associated with the ones noted and which demonstrate the natural character of each group.

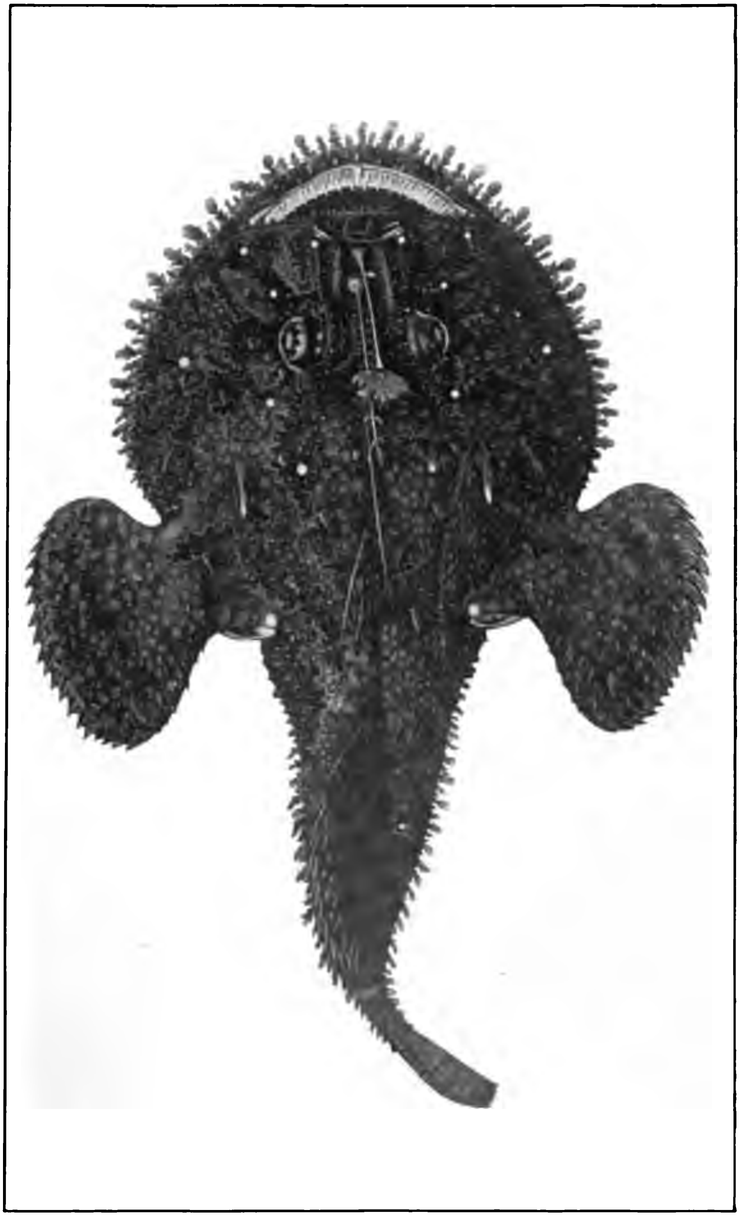


Chirolophius naresii. (After A. Günther)



The Chinese Angler (*Lophiomus setigerus*). (After Temminck and Schlegel)





The Common Angler (*Lophius piscatorius*). (After W. von Wright in Smitt)

DODO SKELETON IN THE UNITED STATES NATIONAL MUSEUM

(To be restored and included in the exhibit of the Smithsonian Institution and National Museum at the Lewis and Clark Exposition, Portland, Oregon, 1905)

NOTES

Dodo Skeleton

The United States National Museum has recently purchased, for exhibition at the Lewis and Clark Centennial Exposition, the skeleton of a dodo, *Didus ineptus*. The specimen lacks the back part of the skull and the ribs, and the pelvis is imperfect behind. Some of the phalanges have been restored. As mounted, the height of the skeleton is 0.66 m. Beside this skeleton, the National Museum possesses a cast of the foot and of the dried head which are in the museum of Oxford University, and also a cast of the skull in the Royal Zoölogical Museum at Copenhagen (Nos. 16,954, 55, 57). By the aid of these casts and the excellent drawings published by Owen in the *Transactions of the Zoölogical Society of London*, it is anticipated that the skeleton can be completely restored without difficulty.—F. W. True.

An Elephant as an Arctic Traveller

[Abstract translated from article by Julius Schott, Director of the Zoological Garden at Copenhagen, in the "Zoologische Garten."]

It has long been known that tropical animals generally endure the lower temperatures of our climate better than polar animals do the higher degrees of heat that occur in our regions. Pachyderms are no exception to this rule. The author of this article saw with the greatest interest in the early days of the year 1900 an elephant in the Berlin garden exposed in the open air to a temperature of —1° Cent. The ground was covered with a thin layer of snow, but the old fellow found himself very comfortable yet showed marked signs of excitement at the unusual sensations.

That elephants bear cold well we have known for a long time, as we have all read in Livy how in 215 B.C. Hannibal succeeded in leading over the snow-covered passes of the Alps a portion of his band of 37 war elephants. However, the world's record for endurance in this line must certainly be given to the elephant "Topsy" belonging to the showman Philadelphia. Five years ago, partially clad in reindeer skins, she undertook a winter journey nearly as far north as the arctic circle.

On February 12, 1900, her trainer found himself in the city of

Östersund in northern Sweden. As business was quite poor there Mr. Philadelphia decided to go to the yet smaller town of Ström where there was at that time a large annual market fair being held. Ström lies about on the 64th parallel of north latitude and its distance from Östersund by a rather narrow road is over 55 kilometers. The weather was cold, the temperature falling during the journey to from —12° to —20° C.

Mr. Philadelphia had made for the animal a covering of reindeer skin and boots of the same material. In this dress she undertook the journey. The snow was very deep and every time that the caravan met a sledge the elephant had to step out of the road and often sank up to her belly in the deep snow. The boots became wet through and had to be taken off. The greatest difficulties occurred when the road passed over frozen water, because the elephant was very unsteady on ice and often slipped down.

On the first day more than half the journey was accomplished. Towards evening the owner of the show hurried forward in a sledge drawn by horses in order to prepare for Topsy a good warm stall for the night. On the second day the caravan arrived at the little town that had never before sheltered such a proboscidean animal. The elephant naturally drew a great crowd of people. The Lapps who, together with the Swedish peasants, frequented the market, could not gaze sufficiently at this wonderful animal from distant India, though the elephant was rather a young specimen, being only some eight years old.

Immediately after the market was over Topsy and her master undertook the return journey, she rich in glory, he in coin. Only a slight frost crack on the external genitals showed the hardships she had endured and this was soon healed up by careful attention. The animal is now in full health and is certainly a remarkable example of training.

RECENT PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST IN QUARTERLY ISSUE, VOL. II, PART 3

No.	Title.	Series.	Price
1559	Smithsonian Miscellaneous Collections (*Quarterly Issue*), vol. XLVII, Part 4 (containing Nos. 1560 to 1570)	M.C. XLVII	.50
1560	FOWLE, F. E., JR. The discrepancy between solar radiation measures by the actinometer and by the spectro-bolometer (*Quarterly Issue*)	M.C. XLVII	.05
1561	BARTSCH, PAUL. A new Philippine landshell (*Quarterly Issue*)	M.C. XLVII	.05

1562	MAXON, WILLIAM R. A new species of Fern of genus Polypodium from Jamaica (*Quarterly Issue*)	M.C. XLVII	.05
1563	HOLMES, W. H. Contributions of American Archeology to human history (*Quarterly Issue*)	M.C. XLVII	.05
1564	STEJNEGER, LEONHARD. The birds of the genus Cinclus and their geographical distribution (*Quarterly Issue*)	M.C. XLVII	.05
1565	RICHMOND, CHARLES W. Description of a new swiftlet from Mount Kina Balu, Borneo (*Quarterly Issue*)	M.C. XLVII	.05
1566	DALL, WILLIAM HEALEY. Report on land and freshwater shells collected in the Bahamas in 1904, by Mr. Owen Bryant and others (*Quarterly Issue*)	M.C. XLVII	.20
1567	SHERZER, WILLIAM HITTELL. Glacial studies in the Canadian Rockies and Selkirks (Smithsonian Expedition, Season of 1904). (*Quarterly Issue.*)	M.C. XLVII	.25
1568	SMILLIE, THOMAS W. Photographing on wood for photo-engraving (*Quarterly Issue*)	M.C. XLVII	.10
1569	GILL, THEODORE. The life history of the Angler (*Quarterly Issue*)	M.C. XLVII	.05
1570	NOTES. Dodo skeleton. An elephant as an Arctic traveller. Continuation of list of publications from Feb. to April, 1905	M.C. XLVII	.05

THE SMITHSONIAN INSTITUTION

Presiding Officer ex officio.—[illegible], President of the United States.
Chancellor.—MELVILLE W. FULLER, Chief Justice of the United States.
Members of the Institution.—[illegible]

Regents of the Institution.—[illegible]

[illegible]

THE NATIONAL MUSEUM

[illegible]

BUREAU OF AMERICAN ETHNOLOGY

[illegible]

INTERNATIONAL EXCHANGES

[illegible]

NATIONAL ZOOLOGICAL PARK

[illegible]

ASTROPHYSICAL OBSERVATORY

[illegible]